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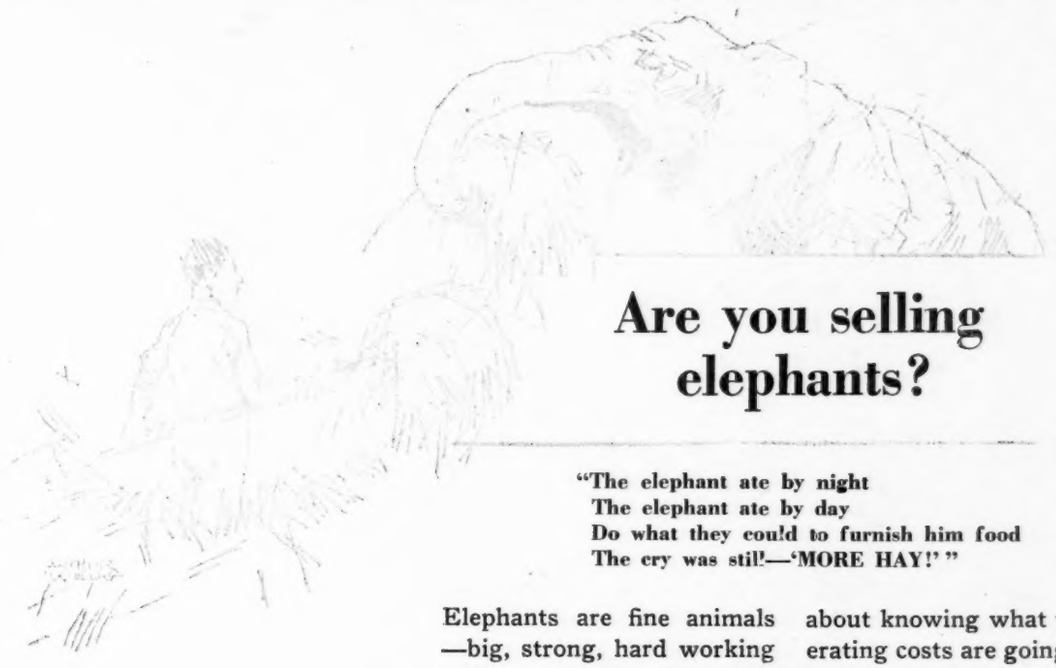


Are you selling elephants?

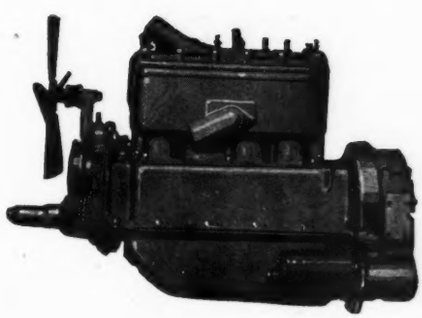
"The elephant ate by night
The elephant ate by day
Do what they could to furnish him food
The cry was still—'MORE HAY!'"

Elephants are fine animals—big, strong, hard working and never tiring—but their cost of upkeep is such that average-salaried men don't buy them any more. Neither, today, do people of limited means buy automobiles that they can't afford to run.

Often the a v e r a g e man stretches himself a bit when he buys a car and he isn't keen about staying stretched indefinitely—so he's insistent about knowing what the operating costs are going to be.

This is one of the reasons back of the "trend to Fours."

They cost less to maintain. And the Lycoming, a highly developed "four" made by a "four" specialist, fully meets the trend because it *IS* economical of upkeep beside affording ample power and flexibility.



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Williamsport, Penn.

Lycoming MOTORS

Entered as second-class matter Jan. 2, 1900, at the post office at New York, N. Y., under Act of March 3, 1879.

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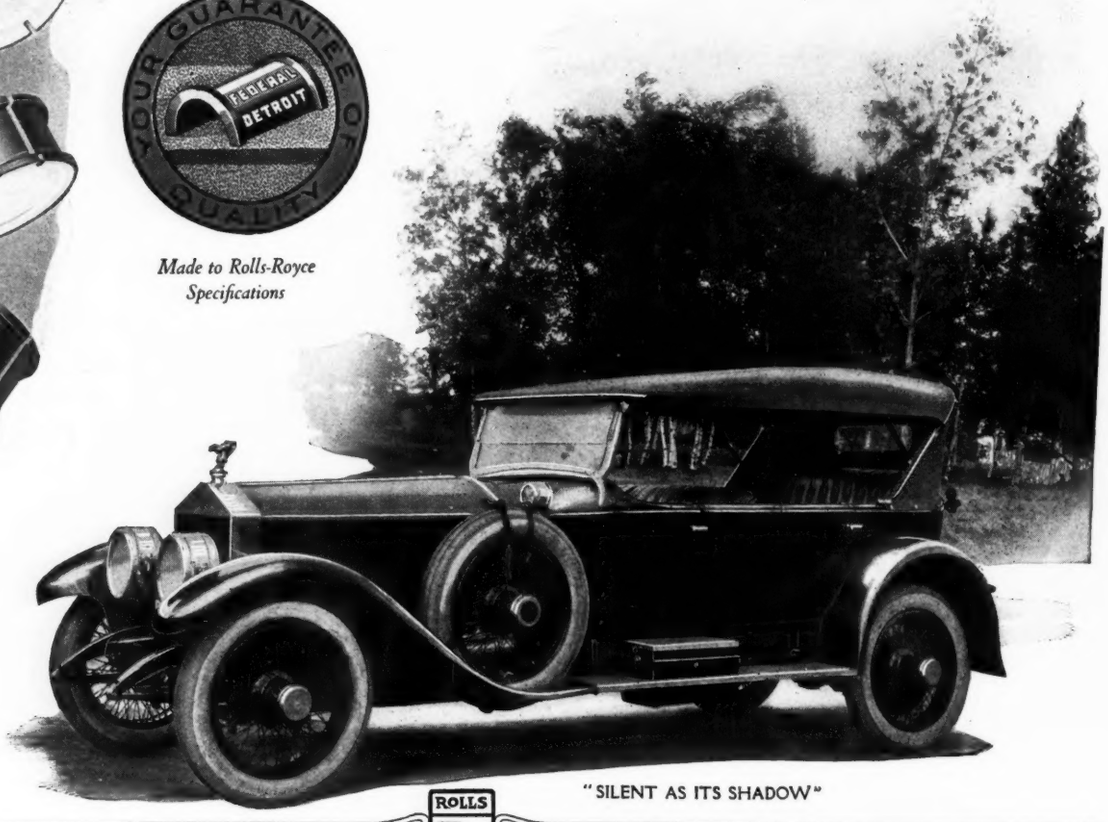
Made to Rolls-Royce Specifications



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DETROIT — MICHIGAN

AUTOMOTIVE INDUSTRIES
The AUTOMOBILE

VOL. XLVI. NEW YORK—THURSDAY, JUNE 8, 1922. NO. 23

Research Essential to Industrial Progress

Opinions must yield to facts. Sound progress can be made only on basis of fundamental truths. Search for such data must be made in fields of marketing, engineering, production, and highway transport.

By David Beecroft

THERE are generally as many different conceptions of what constitutes research as there are people interested in research. One engineer has considered the development of a certain design or patent as research, and correctly so. For convenience, that might be called development research, the kind carried on in many industrial laboratories.

There are a few other industrial laboratories that conduct research of a different character, viz., for the purpose of discovering new facts in an uncharted field, and if possible, the writing down of principles relating to that field and the establishment of new laws.

Our universities and some industrial laboratories are engaged in a field of research which might be designated as intensive research, in that it has to do with the carrying out of very many experiments in given fields in order to determine the relationships existing within the field with the eventual object of discovering principles underlying such relationships followed by the possible formulation of laws applying to such.

Another aspect of a research and one that is preliminary to all research and also essential, is the collection of data relating to the subject in question. In many industries little has as yet been done in this collection of information from various sources. This work might be designated as the source from which research starts. This is the work which to some extent determines the line research is to follow. It gives a conception and a very definite one, of what has been accomplished by different investigators. These data furnish a record of the present accomplishment. They form a base line, so to speak, from which to carry on further researches. The purpose of this first annual research issue of AUTOMOTIVE INDUSTRIES is largely concerned with this collection of data, and the presentation of these, along organized lines, so that they may serve a purpose in facilitating research.

So little is research understood that too often those engaged in it are too frequently considered futurists and theorists and one of our leading research engineers has well expressed it by saying that the man who thinks of to-morrow is generally unpopular with those he is working with to-day. This well sums up the atmosphere in which the research man works. It expresses the estimation some manufacturing executives have of research.

The fact that during the last year or two many companies have dismissed some of the engineers connected with their laboratories and engaged in some form of development for research work, is largely an acknowledgment by such companies that they consider research work highly experimental and only

semi-practical in character. At no time has the discovery of facts, which is in short research, been more essential than at present. To take a leaf from financial practice, we consider first the necessity of budgeting our finances more in times of depression than in days of prosperity. And so in our engineering work, our needs for engineering facts are greater in days such as we are passing through than in times such as war days, when demand greatly exceeded supply.

Viewed psychologically, research is unpopular, as it generally implies an about face—a reversal of position. It means a discarding of old opinions which is a very difficult task, and substitution for these exploded but often long-cherished opinions of new, and sometimes very hard-to-get-acquainted-with facts.

The adoption of the fundamental principle of research implies the discovery and acceptance of facts, and the rejection of these long-held opinions which too often have become part and parcel of ourselves. There is nothing so difficult to rid ourselves of as opinions, perhaps largely personal, and which have consciously or unconsciously become part and parcel of our very existence. It is one of the most difficult tasks to separate ourselves from these opinions. It is akin to a medical operation in which we literally amputate what has become a corporate part of our daily existence.

This psychological aspect of research is more difficult because the examination of oneself is an unusually difficult problem—at times one that approaches the boundary of impossibility. It has been said that self is the most difficult object to analyze. We agree. Consequently, the discovery of the fact that we base so much on mere opinions, the origin of which we are not certain of, adds to the problem of analysis, and it is still harder to cast aside these cherished views that are a part of us, and to discover facts that will replace such faulty opinions. Research really becomes a work of upsetting your past life and building a new foundation on which to survey the future and build upon.

The discovery of new facts by research is long, laborious work, and too often the correct interpretation of these is not carried to its completion. This interpretation is perhaps the most difficult aspect of the work.

There is no royal road to research. He who would find this highway must search it out with the sweat of his brow. Following the thread of experiments, leading to discovery of facts very frequently leads through a labyrinth of years, not infrequently decades, and a lifetime may fleet away without the thread that the research student has been following having led him to the promised field.

Such long-deferred results demand a human tenacity all too rare in days like the present when the search after truth, call it the search after facts if such has a stronger appeal to you, is more needed than at any other time in the century. The too easy profits of the war years in many manufacturing industries had a diametrically opposite effect to what the needs of the present most demanded. It gave many manufacturers an unsound conception of their own importance and the real strength of their positions in industry. It gave a wrong conception of the value and soundness of certain designs, of certain policies, of certain methods, of certain processes. War always creates demand without due regard for the cost of obtaining the end; and too frequently the merchandising fact is eliminated. The problem is one of supplying a demand rather than marketing a product.

Witness our export trade, created during the war, a trade not secured by our own efforts, but rather thrust upon us by other nations not being able to secure merchandise in the markets of Europe where they had been accustomed to securing it. It is not surprising that our manufacturers devoted little effort and fewer dollars to securing facts on this foreign trade, and unfortunately too many in their own self opinion vainly imagined themselves almost super-human merchants in whose hands kind providence had placed some magic wand, the mere possession of which was an open sesame to the business doors of the nations of the world.

A rude awakening came in 1921, and is still with us. Each day impresses us with not only the greater importance, but the undeniable necessity of facts. Hard, cold truths as opposed to deceptively varnished opinions, that an always over-indulgent self is so proud to label its own.

No wonder we shrink from research and all it implies when so frequently our embracing it means a possible sacrifice of those opinions which may be quite a part of the warp and woof of all we are. It may often mean a veritable cutting of all bridges behind us.

The great necessity for all research is to establish the difference between opinions and facts. There is no more difficult line of demarcation to trace than that separating the zone of opinions from the zone of facts in our individual lives. So frequently the opinions have been held by us for so long that we have deposited them in our warehouse of experience as facts. We are very frequently ignorant of their origin and we hold them as facts rather than as opinions until they can be sanely established, a work too rarely done. Too frequently we are too proud to cast aside these opinions. We have had them for so many years, we have depended on them so frequently, they have been our standard in battle, that it is a large sacrifice to admit their error—to admit they do not rest on a sound foundation of facts, but are rather but part and parcel of a most uncertain structure.

When an engineer can classify his own knowledge and can consciously zone it into the two very different groups of opinions and facts, he has taken the first great step in his advancement in research. In research our aim is to work consistently to discover facts and establish principles. Research is concerned with searching after facts and the necessary organization and co-ordination of these facts as they represent principles. This development of facts and the culmination of the work in the establishment of principles is the end to keep in mind. Sometimes facts are as unusual strangers as opinions are highly unreliable friends. Ridding ourselves of these unsound opinions demands a sacrifice equal to that of getting on a speaking acquaintance with the few fundamental

RESEARCH takes the guess out of opinion. It substitutes "I know" for "I think." Sometimes it upsets opinions that have been held for many years. But it points the road to progress.

People that tell the whole truth with brutal frankness are not always popular. They sometimes arouse prejudice by turning the light of truth onto the shadows of opinion. Research is a good deal like these very candid people.

The need for research in every phase of the automotive industry, however, is great. Much has already been accomplished and many activities are now being carried on. This interesting article indicates the path of future development.

THE FIELD OF AUTOM

MARKETING

1. Size of Market Numerically

a. car
b. truck
c. tractor
d. motorcycle
e. other automotive vehicles
f. parts, materials, accessories and equipment

2. Size of Market in Dollars.
(See sub-heads under 1.)

3. Factors Affecting Buying—Buying Values

4. Selling Costs

5. Methods of Distribution

6. Methods of Selling

7. Economic Influences Affecting Buying

8. Relation of Service to Sales

9. Effect of Advertising

10. Foreign Marketing

a. location of markets
b. factors affecting sales of given product in each given market
c. type of selling organization
d. methods of distribution
e. methods of selling

THERMO-DYNAMICS

1. Cycles

a. effect of variations in conventional constant volume type
b. constant pressure type
c. mixed steam and combustion cycles
d. effect of variations in conventional two stroke cycle

2. Expansion and Compression Ratio

a. means for increasing expansion ratio without excessive compression pressures

3. Heat Losses and Transfer

a. rate of loss to jackets under various conditions
b. rate of heat transfer with various surface and gas velocities

4. Effect of Cooling

a. upon efficiency of engine
b. upon temperature of wall surfaces
c. upon maximum temperature and pressure of cycle

FUELS

1. Supply

a. kinds of
b. quantities available
c. refining methods

2. Utilization

a. requirements of service
b. atomization
c. vaporization
d. chemical composition
e. latent heat
f. impurities
g. corrosive action
h. mixture proportions
i. explosive range
j. combustion
k. detonation
l. effect of diluents
m. carbon deposits
n. ignition
o. blending
p. diffusion
q. distribution (in multi-cylinder engine)
r. condensation and deposition
s. absorption (in oil)
t. effect of characteristics on economy

LUBR

1. Oils

a. desirable
b. lubricati
c. heat resi
d. viscosity
e. chemical
f. volatility tests)
g. deteriora
h. oxidation
i. carboniza
j. emulsifica
k. gumming
l. effect of
m. blending
n. effects o
o. corrosive
p. laws of b
q. effect u mechani

2. Greases

a. desirable
b. lubricati
c. chemical
d. heat resi
e. deteriora
f. corrosive

MATERIALS OF CONSTRUCTION

1. Steel and Iron

a. requirements of service
b. physical properties
c. heat treatment
d. means of preventing corrosion
e. effect of impurities
f. alloying methods and materials
g. cause, location and effect of flaws
h. microstructure
i. factors affecting distortion
j. electro-plating
k. welding
l. machining qualities and methods
m. casting methods
n. forging methods
o. hardening and decarbonizing methods

2. Copper Alloys (Brass and Bronze)

a. requirements of service
b. physical properties
c. heat treatment
d. corrosion at various temperatures and means for its prevention
e. effect of impurities
f. alloying methods
g. cause, location and effect of flaws
h. microstructure
i. welding and soldering
j. casting methods
k. electro-plating
l. machining qualities and methods
m. effect of cold working

3. Aluminum Alloys

a. requirements of service
b. physical properties
c. heat treatment
d. corrosion and its prevention
e. cause, location and effect of impurities
f. alloying methods
g. microstructure
h. welding and soldering
i. casting methods
j. machining qualities and methods

4. Bearing Materials

a. requirements of service
b. physical properties
c. wearing qualities
d. non-scoring qualities
e. friction coefficient
f. optimum alloys
g. type requiring no lubricant
h. optimum thickness
i. microstructure
j. corrosion

5. Wood

a. supply
b. requirements of the service
c. physical properties
d. effect of moisture content
e. preservation
f. fatigue
g. causes of deterioration
h. brashness
i. shock absorbing qualities
j. seasoning and drying methods
k. kinds for different purposes
l. laminated members
m. moisture absorption through different protective coatings

6. Rubber

a. requirements of service
b. physical properties
c. supply natural and synthetic
d. effect of compound and curing on life or rate of wear
e. aging
f. effect of light and temperature on life
g. internal power losses (hysteresis)
h. cementing
i. vulcanizing methods
j. compounding
k. optimum composition

7. Asbestos

a. requirements of service
b. physical properties including effect of temperature
c. factors affecting durability
d. abrasion
e. friction qualities
f. methods of compounding
g. optimum composition

8. Leather

a. requirements of service
b. physical properties
c. factors affecting durability

9. Fabric

a. requirements of service
b. physical properties
c. holding finish coating
d. durability of colors (fading)

10. Felt

a. requirements of service
b. physical properties
c. factors affecting durability
d. ability to exclude dirt
e. oil retaining qualities

11. Glass

a. requirements of service
b. factors affecting friability
c. color
d. transparency
e. surface regularity

12. Celluloid

a. requirements of service
b. factors affecting durability
c. means for preventing scratching
d. physical properties
e. color
f. transparency

13. Paints and Varnishes

a. requirements of service
b. factors affecting durability
c. physical properties
d. methods of application
e. factors affecting drying

14. Glue (Celestin and Casein

a. requirements of service
b. optimum composition for various conditions
c. factors affecting strength and durability
d. methods of application

PERFORMA

1. Complete Vehicles

a. requirements of service
b. factors affecting safety
c. effect of various factors on fuel economy
d. relation of service to life of vehicle and cost of operation—?
e. economic size for various service
f. factors affecting durability
g. friction losses
h. riding qualities
i. factors affecting stability
j. windage
k. effect of vibration on life
l. braking
m. effect of vehicle on the road
n. effect of the road on the vehicle
o. optimum speed
p. accelerating ability
q. accessibility as affected by various types of construction
r. relation of weight to economy and life of vehicle
s. factors affecting skidding

2. Power Plant

a. requirements of service
b. optimum size, speed, No. of cylinders, type of construction, etc. for given performance
c. factors affecting efficiency
d. method of mounting
e. balancing and other factors affecting vibration
f. material for various parts
g. design factors as affecting starting
h. type of manifold, carbureter, etc., for maximum economy
i. effect of design factors on combustion
j. effect of piston and ring design on distortion power, friction and economy in oil and fuel
k. effect of type and construction of ignition units on performance
l. structural problems
m. utilization of heavy fuels

3. Cooling Syste

a. requirements of
b. heat transfer their applicatio
c. relative advan air, oil, water cooling
d. optimum capacit sions, and ma radiating surfa
e. prevention of clogging and c
f. relative advan forced and ther cooling
g. factors affecti speed, efficie quietness of fa driving mecha
h. non-freeze solut

4. Engine L System

a. requirements of
b. factors affecti bility
c. effect of type bility of engine
d. optimum pressu
e. means for leakage
f. methods of parts outside

5. Electrical Sys

a. requirements of
b. type, timing struction of system
c. study of facto trouble (reliab
d. type, location a ing of gene starter
e. character of method of inst
f. type of constru carrying mean tery
g. factors affecti bility and du spark plugs
h. factors affecti life
i. contact materia

UTOMOTIVE RESEARCH AND D

LUBRICANTS

1. Oils

a. desirable characteristics
b. lubricating value
c. heat resisting qualities
d. viscosity
e. chemical structure
f. volatility (fire and flash tests)
g. deterioration
h. oxidation
i. carbonization
j. emulsification
k. gumming tendency
l. effect of dilution
m. blending
n. effects of adulterants
o. corrosive action
p. laws of bearing lubrication
q. effect upon wear and mechanical efficiency

2. Greases

a. desirable characteristics
b. lubricating value
c. chemical composition
d. heat resisting qualities
e. deterioration
f. corrosive action

TEST METHODS AND APPARATUS

1. Strain analysis
2. Development of better instruments
3. Development of better methods

HIGHWAY

1. Economics

a. traffic studies
b. community needs
c. cost of transport
d. economics of location
e. financing
f. highway valuation

2. Operation

a. control of traffic
b. accident insurance
c. planning systems of transport
d. financing
e. distribution of costs
f. maintenance systems
g. maintenance machinery
h. maintenance methods
i. trail marking
j. safety

3. Road Design

a. subsoil studies
b. base course
c. surface
d. cross section
e. loads

f. design
g. volume
h. reinfor

4. Road ing to th

a. design
b. effect
c. surface
d. alignm
e. cross
f. safety

5. Const

a. materi
b. mixing
c. placing
d. road t
e. design roads
f. drainag
g. impact
h. reinfor
i. inspect
j. plant d
k. cost a
l. constru

PERFORMANCE AND CHARACTER OF CONSTRUCTION

3. Cooling System

a. requirements of service
b. heat transfer laws and their application
c. relative advantages of air, oil, water and steam cooling
d. optimum capacity, dimensions, and materials of radiating surface
e. prevention of scale, clogging and corrosion
f. relative advantage of forced and thermosyphon cooling
g. factors affecting size, speed, efficiency and quietness of fan and its driving mechanism
h. non-freeze solutions

4. Engine Lubrication System

a. requirements of service
b. factors affecting reliability
c. effect of type on durability of engine
d. optimum pressure
e. means for preventing leakage
f. methods of lubricating parts outside crankcase

5. Electrical System

a. requirements of service
b. type, timing and construction of ignition system
c. study of factors causing trouble (reliability)
d. type, location and mounting of generator and starter
e. character of wiring and method of installing
f. type of construction and carrying means for battery
g. factors affecting suitability and durability of spark plugs
h. factors affecting battery life
i. contact materials

6. Power Transmitting Units

a. requirements of service
b. effect of gear tooth form on wear and efficiency
c. other factors affecting efficiency
d. gear design as affecting performance
e. cause of noise and means for preventing it
f. lubricating problems
g. optimum type of construction for universal joints
h. advantages of cushioning of driving members
i. factors affecting ease of engagement in clutches
j. factors affecting wear of clutch facings
k. means for cooling clutch parts
l. gearset location as affecting accessibility
m. structural problems
n. factors affecting efficiency
o. possible improvements in type

7. Brakes

a. requirements of service
b. optimum type for safety
c. cooling means
d. factors affecting durability and freedom from noise
e. effect of construction on braking effect and weight
f. study of various factors affecting durability

8. Axles

a. requirements of service
b. relative advantages of various types of construction
c. efficiency of various types of gearing with various lubricants
d. optimum gear ratio for various conditions
e. effect of weight on tire life and riding qualities
f. effect of various factors on steering

9. Wheels

a. requirements of service
b. factors affecting durability
c. effect of weight and material on tire wear
d. relative shock absorbing ability
e. optimum type for various applications
f. type of rim construction

10. Tires

a. requirements of service
b. effect of loading on fuel economy
c. factors affecting durability
d. factors affecting frictional losses

11. Springs

a. requirements of service
b. optimum type for given conditions
c. factors affecting weight—sprung and unsprung
d. factors affecting durability
e. means of lubrication
f. factors affecting riding qualities
g. effect of design on durability of vehicle

12. Frame

a. requirements of service
b. structural problems
c. factors affecting strength and rigidity
d. optimum method of riveting
e. factors affecting selection of materials

13. Chassis Lubrication System

a. requirements of service
b. relative effectiveness of various types
c. means for preventing waste of lubricant
d. means for preventing damage due to dirt and moisture
e. possibilities of bearings requiring no lubricant

14. Lights

a. requirements of service
b. means for preventing glare
c. better distribution of light on road
d. factors affecting durability (finish, filaments, etc.)
e. optimum arrangement of lights and reflectors in buses

15. Steering Gear

a. requirements of service
b. factors affecting safety
c. effect of various factors on ease of steering

16. Body

a. requirements of service
b. optimum character of construction for minimum weight and maximum durability
c. type of construction to facilitate rapid and durable finish
d. factors controlling heating and ventilation of closed bodies
e. factors affecting wind resistance
f. cause and elimination of noise

17. Trimming

a. requirements of service
b. finish as affecting ease of cleaning
c. relative suitability of various fabrics for various uses
d. type of upholstery for maximum comfort of passengers

18. Muffler

a. requirements of service
b. factors affecting silencing
c. factors affecting back pressure
d. structural problems

1. Airpl

a. service
b. resista
c. stress tural
d. metal
e. substit facin
f. landing
g. wing adjus
h. contro
i. fire p tingu
j. weatne

2. Airsh

a. servic
b. resista
c. stress tural
d. propel drive
e. gas p fabri
f. hull v mal
g. moori equi
h. contro dyna
i. fire p tingu
j. weath
k. gas hand
l. gas v

3. Helic

a. servic
b. stabil
c. efficie
d. glidin

D DEVELOPMENT

GHWAY

f. design of integral slab
g. volume changes
h. reinforcing

4. Road Design as Relating to the Vehicle

a. design of vehicle
b. effect of design on loads
c. surface
d. alignment
e. cross section
f. safety

5. Construction

a. material
b. mixing
c. placing
d. road testing methods
e. design of experimental roads
f. drainage
g. impact on bridges
h. reinforcing
i. inspection
j. plant design and control
k. cost accounting
l. construction contracts

LABOR

1. Stabilization of Employment

a. general industrial stability
b. study of business cycle
c. possibilities of cooperative action by employes
d. unemployment statistics (see Mitchell for Home Outline)

2. The Individual Plant

a. influence of job type on individual efficiency
b. relation of supervision costs to individual responsibility
c. relation of physical fatigue to production efficiency
d. relation of metal fatigue to production efficiency
e. cost of labor turnover
f. causes of labor turnover
g. causes of lack of efficiency on part of worker
h. methods of increasing efficiency
i. relation of wages to production efficiency
j. methods of wage payment
k. bonus schemes
l. employe stock owning

PRODUCTION

1. Relation of Worker to Production Efficiency
2. Cost Accounting
3. Machine Design
4. Departmental Layout
5. Machine Placement
6. Obsolete or semi-obsolete machinery
7. Relation of Parts Design to Production Efficiency.
8. Handling and Storage of Materials and Product
9. Machining and finishing methods
10. Effect of Methods on Quality and Rate of Production
11. Routing
12. Packing and Shipping Methods.

AERONAUTICS

1. Airplanes

a. service needs
b. resistance reduction
c. stress analysis and structural refinement
d. metal construction
e. substitutes for fabric surfacing
f. landing run and take-off
g. wing arrangements and adjustable wings
h. control and stability
i. fire prevention and extinguishing
j. weatnerproofing

2. Airships

a. service needs
b. resistance reduction
c. stress analysis and structural refinement
d. propeller disposition and drives
e. gas proofing of fabric and fabric substitutes
f. hull ventilation and thermal insulation
g. mooring methods and equipment
h. control, stability and dynamic lift
i. fire prevention and extinguishing
j. weatherproofing
k. gas purification and handling
l. gas valves and controls

3. Helicopters

a. service needs
b. stability and control
c. efficiency
d. gliding ability

4. Gliders

a. practical uses and service needs
b. resistance reduction
c. structural refinement
d. stability and control

5. Hulls and Floats

a. service needs
b. structural refinement and weight reduction
c. resistance reduction
d. shock absorption and flexibility
e. weathering qualities and seaworthiness
f. metal construction

6. Propellers

a. service needs
b. efficiency
c. weatherproofing and wood substitutes
d. silencing
e. pitch adjusting and reversing mechanisms

7. Instruments

a. service needs and altitude effects
b. engine instruments
c. navigating and flying instruments
d. ordnance instruments
e. recording apparatus

8. Navigation

a. methods
b. observation and calculating apparatus

9. Landing Fields and Airways

a. service needs, day and night
b. economic hangar construction
c. field arrangements and wind screening
d. airplane and airship mooring
e. drainage and runways
f. fire prevention and extinguishing
g. marking, color visibility and signalling
h. wind direction and speed indicators
i. launching and arresting mechanisms

10. Commercial Operations

a. economic size and characteristics
b. economic distances for operation
c. operating cost reduction
d. passenger facilities
e. despatching
f. operation with poor visibility
g. Emergencies, life saving and salvage
h. mail dropping and picking-up equipment
i. business sources, new uses and extension
j. regulation

11. Miscellaneous

a. leakproof tanks, pipe and fittings
b. automatic cameras and aerial surveying
c. radio and direction finding
d. radio antennae for use on surface
e. parachutes and liferafts
f. automatic pilots
g. accidents
h. new applications of constructional materials
i. direct (jet) propulsion

12. Radiation

a. service needs
b. reduction of resistance of radiators
c. Adjustment for temperature
d. utilization of wing and body surfaces for radiation

13. Aerodynamics

a. wing curves, military and commercial
b. propeller model tests
c. airship hull tests
d. airplane bodies, military and commercial
e. resistance of appendages
f. wing arrangements
g. tapered wings and slotted wings
h. wing, body and propeller interference
i. performance computations and corrections

14. Hydrodynamics

a. resistance of hulls and pontoons
b. planing of hulls and pontoons
c. control of planing speeds

facts, or better still with well-established principles.

May we borrow an example from our highway situation of to-day.

We have nearly as many opinions as to what is the correct way to build a highway and the maximum load to carry thereon and the maximum permissible speed for travel, as we have highway engineers, motor truck engineers and transport engineers. But in the midst of all we have a famine of facts on highway design and highway transportation. No one engineer has yet measured and set down in figures, the facts on the transportation costs on a cement highway, a gravel highway, a brick or other form of highway. No one engineer has yet gotten the facts on the life of different kinds of highways for a given type of truck, or for the movement of a different quantity of commodity at different speeds and under varying conditions. We are short on highway, and highway transportation facts.

Unfortunately, we are very long on opinions. These opinions are the stumbling blocks to that rapidity of progress we desire. These opinions so often are of such long standing and so many reputations, be they big or small, are founded on these opinions, that it is a major operation in the life of the individual to change his opinion, and too frequently it is harder to get a research fact started than for the camel to pass through the eye of the needle. In no other sense is the fact that we are chained to tradition so true and so almost fatal to progress, as in this clinging to opinions and the lack of energy to see greater success in broadening our stock of facts than in clinging to our unreliable opinions.

"RESEARCH gives to a man nothing that he cannot deduce himself, but it gives it to him easier and quicker."

One great need to-day is the training of men competent to carry out intensive research. Industries can profitably co-operate with the universities in the attempt to meet the demand for competent research workers.

The traditional adherence to opinions was well exemplified recently by a New England highway official, who expressed the opinion that the maximum gross motor truck load that should be permitted on the highways be ten tons. No reasons for such an opinion were given, the foundation for such being merely a hunch. The reason back of the hunch was largely based on a query as to where the money was to come from to build the future roads for his state. His suggested source of revenue was to tax the motor truck and make the vehicle that wears out the roads pay for their maintenance and construction—another opinion. He failed to appreciate the fundamental fact, or better still, the fundamental principle, that the community in which transportation is carried out, pays the cost, whether that cost is on highway construction, or highway maintenance, or high intitial price of motor truck, or high maintenance of truck, or high transportation cost, due to not using the most economic unit of transportation and employing this unit in the most economic manner. It is the citizen of the community who pays transportation bills. He may pay it in the form of a high state tax, or county tax, or a higher price for his milk for breakfast, or his loaf of bread, or every other commodity that enters into his business or domestic sustenance.

The illusive thread that will lead us out of the highway transportation dilemma, is the discovery of facts, and the recent research work of the Bureau of Public Roads, supplemented by work in some of our universities and state highway departments, will eventually bring to the surface the fundamental facts on highway transportation costs, and with these known the broad underlying principles can be discovered and the economic laws of highway transportation drafted. Throughout this work the struggle will be one of facts against well entrenched and traditional opinions.

Charles F. Kettering recently drew a practical analysis between research and finance which aids in clarifying our conception of the role that research should play in an industrial organization. He described research as the mechanical budgeting of our industries just as we budget our finances over a year or other period. What financial man, what president of a large factory, would base his year's program on a budget not based on facts, definite figures, expressed in dollars and cents?

What board of directors at an annual meeting would accept from the treasurer what was merely an opinion as to the assets and liabilities and which was not supplemented by specific figures to establish such opinions. The balance sheet of an organization must be accurate to the last cent. You never saw a statement that neglected the cents. There is no room for opinions on the financial balance sheet of a company. Its entire use is based on its adherence to facts. It is a reliable compilation of dollar-and-cent facts.

Research which results in the accumulation of facts accomplishes for engineering, just what facts do to the balance sheet. They take the guess out of opinion, if the opinion is not upset entirely. The manufacturer who hopes to make engineering progress by basing it on opinions is in a very precarious position and pursuing a highly uncertain and most improbable path to advancement. Here facts are merely accurate units for measurements of results as contrasted with estimates or opinions. These facts are, or should be, definite milestones by which to blaze out the trail of progress.

What have our recent researches to motor fuels in the last eight years consisted of more than the discovery of facts and the interpretation of these so as to discover underlying principles? Different schools of fuel research have directed effort along certain lines so that each school seeks facts—not opinions. One school seeks facts in speed of flame travel, facts on speed of combustion, tries to measure and express in figures explosion pressures—in a word, to write down in indisputable figures, the explosion transaction, just as the business house writes down its profit or loss in a series of fundamental facts rather than in paragraphs of financial opinions.

Research work should never be confused as being a promotional department in an organization. Perhaps this statement is paradoxical in that the only progress that is enduring is that what is founded on facts. In this sense, research is heart and soul progressive, but a line must be drawn between the words progress and promotion. The ideal promotional work should be based on research, but this is not the generally accepted interpretation of the term. Insofar as promotional work is founded on facts, then research can be promotional, but too frequently promotional activities rest on opinions, in which facts unfortunately play too minor a rôle.

Research has not always to do with engineering problems and not infrequently what might be designated as psychological research has a more direct bearing on the development of an industry than any technical research might have. There are many examples in industry where a certain engineering design of apparatus has been

"RESEARCH is not going to deprive any engineer of his present work. It is going to enable him to obtain results which otherwise might not be possible. It is going to provide him with an arsenal well stocked with knowledge that will help speed his efforts to better work."

mechanically correct and has not employed any new engineering parts or relationships, but the success of which device has been poor. In short it has not had a psychological appeal. The success of the company is generally measured by its financial success and where the product may be correct from an engineering viewpoint, but does not appeal to the public, the end of that company is failure.

A psychological research may be necessary. Any piece of automotive or other apparatus to sell must have a human appeal—must coincide with the other standards of human development—must admit of application in accord with the present standards of life. For example: You might market an electric machine for the farm that involves nothing new in the electrical field, that is designed in accord with established facts, that has no unknown relationship existing among parts, but yet such machine might prove a failure if its application and operation are not attuned to the capacity of the farmer or not in sympathy more or less with his scheme of life.

Here the necessary research consists primarily in a search after psychological facts, rather than technical facts. The success of a company manufacturing the product is as dependent on the psychological facts as on the electrical facts, and here the business is but as strong as the weakest link. How often have you seen a product of accepted merit prove a failure due to its poor psychological appeal or because it is in violation of psychological principles and not resting on psychological facts.

The laws of the mind have not been nearly as definitely defined as the laws of nature, as the laws of mechanics but unfortunately there are manufacturers who have never heard of the science of psychology and they have constantly wondered why with all their engineering knowledge and all their manufacturing skill their efforts have not lead to success.

There are physiological researches that are as much needed as engineering and psychological researches are. The seat of a motor car and the general co-ordination of controls and measurements may be cited in explanation. To produce a comfortable seat, and it is agreed they should be comfortable, and admitted by others they can be, requires research of the human body, a study of the skeleton, muscles and tendons. A position of a muscle in repose as well as in tension should be known. A great portrait painter or any great animal artist must be as great a student in the proportions of anatomy and the relations of muscles to actions as in combinations of color or in the technique of pigments. The artist must discover the relationships of certain facial expressions with muscular tension, bone position, etc. He has the engineering of the physiological as well as the automotive engineer. So the motor car engineer should know the facts of the human body, the skeleton system, the muscular system and the physiological system in order to produce the best results. Our great musicians, both vocal and instrumental, have learned the necessity of physiological researches. There is not a great pianist but who performs in obedience to underlying principles governing movements of the human hand. The same applies to the great vocalist. Success in either is based upon facts—facts developed by research.

A factory research department because of the indefinite character of the work to be done, may prove to be a non-remunerative department if an effort is made to measure its value month by month. The fact that it is a research department too often presupposes that it is subject to no laws and requires no direction. There is no Blue Book that tells what corners to turn at as the engineer vainly endeavors to discover the route he is seeking across some uncharted plain. It may take years of continuous study to discover the direction in which to go and more years to chart with a degree of accuracy the route to that goal and still more years to discover what units of measurement are best applied to the work and what are the underlying principles and to write the specific laws that govern.

The presence of all these unknowns does not make impossible the pursuit of a definite program and the shutting out of irrelevant experimental work. The initiative of the research engineer must be conserved, in short, encouraged at every turn. But this encouragement can be accomplished none the less. If a gunner with a long distance piece, cannot see his target, even if he knows the position, he should, by application of the laws of ballistics definitely train his gun upon it. It profits little to merely shoot in the direction of the target. The explosive charge, the weight of projectile and characteristics of the gun, must all be brought into relationship before he hits the mark. He must correct for windage and take recognition of other interfering factors. Too many researches are merely firing in the direction of a possible target without bringing the facts of science constantly to bear on the task.

The origin of research is always found in a lack of satisfaction or lack of efficiency of some existing product, process, condition or state.

Our motor fuel may not burn in the combustion chamber to our satisfaction.

Our engine design may not give the amount of power per unit of fuel consumed we consider it capable of.

Our motor cars to hold the road as we think they should, have to weigh too much and we begin researching on roadability and unsprung weight.

Our commercial airplanes are not built with sufficient reliability, the public has opinions on accidents and we start to discover the facts that compose the alphabet in safety of commercial aviation.

Our engine manifolds do not distribute the mixture of air and liquid fuels of the different cylinders as they should and we start to write down the facts and aim to formulate the laws governing manifold design.

Our farmers do not purchase house lighting units in quantities as we think they should, and we institute a psychological research to discover reasons why and to find out what laws of psychology are directly concerned and wherein we violate them.

We are not certain of the wear of pneumatic tires upon heavy vehicles using our highways and we set out to measure the destruction and to write the facts.

We are not satisfied with the endurance of paint on wood surfaces and research to learn the reason why and possibly formulate a law.

Believing that the ability of a motor vehicle to hold the highway at speed, in other words to possess good roadability, is too low, we set out to study every detail in steering parts and if possible set down the mathe-

matics of every factor entering into roadability and to establish the relationships existing among these different factors.

Countless other examples might be cited. Each represents a research. Each is a definite target on which to concentrate. In each the problem can be fairly definitely specified.

Each research generally begins with the bringing together of all literature relating to the subject of the proposed research. This literature generally represents the sum total of existing information. This information has been studied, analyzed, arranged, rearranged and generally results in suggesting the many avenues or directions in which more information is necessary. It is a good chart by which to direct the work.

The research engineer should constantly have impressed upon him the fact that he is working on some definite problem that eventually will become an economic factor in industry.

He should always be conscious of the fact that he is not working on some problem, the solution of which may result in a process or device that will not prove an economic factor in the industry concerned. The keeping of this economic character of the process or the device is a safety valve in research work. It is a yard stick by which the progress of research can be gaged, when definite measurements of such progress may not be possible.

This definite factor in research work does not hint at putting blinders on the personal initiative of the research engineer. Some of our most useful research departments and most able research engineers are those who are required by their organizations to financially budget their different researches for a year and to periodically report progress of work. Research effort must be carried on with a definite objective of economic value constantly in mind. A new lubricant may have been discovered and definite laws for its manufacture written, but unless the machine equipment necessary to produce it is designed and built the research cannot be said to be complete. It then becomes incumbent on the research department to design a machine or a system of machines or processes that will commercially produce the lubricant or other product, and when this is done the work of the research engineer on that job is ended. The job is not complete if the necessary wherewithal to render the result of the research commercially successful has not been carried out.

This brings us to the state of transition between the research department and what might be designated as the commercial manufacturing department of the company. The research department develops the product to the commercial stage and produces the tools that may be necessary to manufacture it if necessary. The factory takes it and all problems relating to multiplication of production methods are factory problems and not research department problems.

Different companies in different industries vary widely in the practice of covering relations between the research department and commercial manufacture.

Some rather definite regulations have been laid down: One organization will not permit the factory manufacturing department to alter a fundamental of design which might not only interfere but quite upset a basic principle constituting the foundation on which the machine is designed. The manufacturing department is prone to see only the production phase of the job, and numerous examples could be cited of where a manufacturing organization has almost entirely destroyed the efficiency of the device. By alterations and design, intended to facilitate production, and perhaps reduce manufacturing cost, but at the expense of the engineering principle involved. This suggests the imperative need for close co-operation between the research and the manufacturing departments and vice versa. Not infrequently the great, if not the greatest problem, of the research department, is to upset the opinions and prejudices of the designing engineer. This is the oft referred to contest between facts and opinions. This close relationship between research and manufacture suggests what some term contact and others liaison work. The research engineer will generally find it desirable to keep in constant touch with the engineering, manufacturing and production departments long before he is ready to turn over a job he has been working upon. The oft heard remarks, that it will not work, it cannot be done, I know better, it never has been done that way, and others, suggest the task the research engineer has on his hands to convince the designing engineer. It is poor policy to try to do this conversion all at one time. Let us keep in mind that opinions are the most fatal enemies of research and that engineers are hugely human, much as we may think otherwise, and that their very education following channels of tradition, constitutes the bulwarks for the defense of these opinions.

"MEN should gather the greatest satisfaction from the progress made in the search after truth. There is nothing so far removed from us as to be beyond our reach or so hidden that we cannot discover it, provided only that we abstain from accepting the false for the true and always preserve in our own thoughts the order necessary for the deduction of one truth from another."—Rene Descartes.

It is not surprising that in industries leading manufacturers with research departments insist on all modifications made for production or other reasons by the designing engineer be approved by the research engineer, solely to make sure that the underlying principles have not been disturbed.

The greater necessity for research in all departments of the automotive industry at this time is largely because of the greater demands from the public for more value per dollar expended. No one has yet weighed the effect of the great wave of economy that has been operating for upward of two years. No one has accurately measured the influence that it is going to exert on the products to be manufactured in the next few years. In no two previous years has the public studied prices and what is received for them so much as since the spring of 1920. The public has lived through a zone of price alteration, not local to the automotive industry but general to all industries. This has led the public to scrutinize values as never before. The uncertainty of the immediate future has introduced a thought of conservatism that formerly was not common with our buying public. The manufacturer finds himself faced with the problem of not only giving a better vehicle, if he is to build for the future, but also one at a fair price. The thought of merit in a product is more dominant with the buyer than formerly.

The second reason why research is so essential at the present time is that the great problem of production which absorbed the activities of manufacturers from 1912 up to 1920 has largely ceased. The question with the manufacturer is not how can I build more or in

greater numbers, but how can I build better and lower the manufacturing costs as well as the marketing and maintenance cost in every possible way. This situation has caused manufacturers to study markets as never before. The let-up in tractor sales led one of the best established tractor makers to institute a research on the buying capacity of different types of farming for his particular tractor. The study included an analysis of all crops and the zoning of the country into agricultural divisions that possessed similarity of climate, soil and cultivation characteristics. The facts developed by this research had a most important bearing on the manufacturer who made the surprising study that he was developing approximately 75 per cent of his manufacturing capacity to what constituted 15 per cent of the possible selling field for his product.

Merchandising Studies

Such a program was not an economic one, and the manufacturer by virtue of the facts developed, which contradicted long held opinions, was induced to program a new line of product, one that would better coincide with the status of the market. This simple example indicates how essential research is in the marketing field as well as in the field of design and how essential it is for any corporation to rest on a foundation of facts not only so far as the design of its product is concerned, but also so far as the possibilities of merchandising enter into it. This rounded-out character of research in any industry must constantly be kept in mind.

A motorcycle manufacturer, believing that the side delivery car offered one of the cheapest methods of light parcel delivery, looked with optimism on the future of such a field, but was surprised that the sales did not measure up with his conception of what they should be. A research carefully and broadly carried out disclosed the fact that while the side delivery car offered such possibilites for transportation, yet the driver was the obstructing factor. The driver could not be afforded necessary weather protection as in a conventional four-wheel type of vehicle. The research disclosed the fact that in the snow belt the side car encountered difficulties that the conventional four-wheel type did not have to cope with. In this case the fundamental research was a personal factor. It might be classified as a psychological one, and where the success of an industry is dependent on the strength of the weakest link, the psychological aspect may be of greater importance than the technical one.

The automotive industry faces to-day the necessity for a comprehensive research in transportation that will supplement the steam railroads and the electric railroads. The use of the internal combustion motor car on steam railroad lines is in its infancy in America, although cars of this type have been in use for many years. The movement has not been accepted and studied by the railroad people as it should have been. To-day there is grave possibility that this type of vehicle may be severely handicapped by restrictions of various characters considered necessary by the railroad interests. Only a co-operative research or study by the automotive industries and the railroad industries will evolve with the least expenditure of money and effort the most economic type of vehicle for this field. Individual researches conducted by each party will produce results that may not coincide, but by mutual effort better and speedier results will be obtained.

The past two years have witnessed factors injected into the controversy between electric railroad lines and motor buses that indicate how necessary sane researches after facts are in this field. The controversy has shown large corporations endeavoring to inject certain types into the field, largely because of vested interests and not because of the economic factors involved. In older established industries, such as the steam railroads and electric lines, opinions are naturally harder to remove than in newer fields of transportation. A recent example of this was when the American Engineering Standards Committee called a conference for the consideration of unifying colors in traffic signals, the railroad and electric railway interests immediately set about to make certain that their existing codes of colors were not altered but that all the alterations should be made in color signals as relating to the motor vehicle and the highway. There was no inclination on the part of either the steam or electric interests to enter on an even basis into the study, but rather hedged by traditional opinions that what they were using was right, they only saw one avenue of operation, namely, that all changes should be made in the newer forms of transportation. It is but natural to expect that such a stand should have been taken, and it is largely because of conditions such as this that researches or the establishment of facts as opposed to opinions are so necessary.

Examples as to why researches are necessary in so many fields of the industry could be cited ad infinitum. Accompanying this issue of AUTOMOTIVE INDUSTRIES is a supplement in the form of a chart that suggests the avenues along which researches should be carried out.

This chart was constructed with the thought that it should be comprehensive in character; that it should include all of the various lines of investigation from which the automotive industry will draw in determining its future practice. So far as we know, this is the first attempt of this kind that has been made. It is obvious that we have not accomplished our purpose in every detail. There may even be items of considerable importance missing from the tabulation.

Suggestions as to additions or corrections will be welcomed from representatives anywhere in the industry. Such criticism will aid in the development of a comprehensive picture of essential research activities and in bringing about a fuller recognition of their importance in maintaining the high standards of progress which have characterized the past growth of the automotive industry.

Highway Outline Good Example

For the outline of Highway Research we are indebted to the Advisory Board on Highway Research, from whose outline we have taken the highway part of the chart. This outline, prepared under the direction of Professor Hatt, director of the Advisory Board on Highway Research, presents an excellent example of the sort of basis needed throughout the field of automotive research. It comprises a thorough analysis of all the problems involved and a systematic classification of the various items in such a way as to give a vivid picture of the entire field.

The items listed in the chart are those which call for investigation, support and interest on the part of the industry.

The chief purpose of the chart is to visualize the vast extent of the research topics of direct or indirect interest to the automotive executive. In certain parts of this broad field the automotive industry must be the prime mover in the execution of the studies and investigations. In other instances responsibility for the actual work rests with allied industries. In these cases the automotive manufacturer is interested primarily in the results achieved and in the application of those results to automotive problems.

Market Research Activity Increasing in Passenger Car Field

Comprehensive outline of procedure needed. Research departments established in many factories. Retail sales laboratory is being operated by one large producer. General business surveys applied to current sales effort.

By Norman G. Shidle

SPORADIC effort and greatly increased interest during recent months have characterized market research in the passenger car field. Activities range from the collection and analysis of monthly registration figures to the operation by the manufacturer of a home retail branch as an experimental laboratory in retail automobile selling. Statistical departments are maintained in a number of factories, but few of these carry on what may properly be termed market research. Departments have been established in one or two cases which are given over to the collecting of various data affecting sales, to the analyzing, correlating and interpreting that data into terms of production schedules, distributor quotas and administrative claiming.

Comparative month to month examinations are usually made of sales figures as compared with competitive sales. One large manufacturer gets weekly telegrams from factory representatives in regard to the business and economic situation in nearly a hundred territories. Considerable study precedes the establishment of distributors' quotas in a few cases.

IN only one or two cases, however, has any definite continuing program of market research been laid out and followed through over a period of time. In most instances the object has not been to complete a research study to determine fundamental rules for permanent procedure, but rather to develop enough data to give the answer to a pressing immediate business problem.

Studies of this kind are included, to a large extent, in the field of competitive research, having to do with the development of a particular product rather than with the establishment of new principles of operation useful for promoting general progress.

Thus, it may be said that pure research in connection with passenger car marketing has been almost entirely lacking up to the present time. This is rather natural as there are many difficulties in the way of an individual company when it attempts alone to conduct research of a very broad character. Such general research is essential, however, as a basis for intelligent individual studies by single manufacturers.

More than a year ago one car manufacturer established a Commercial Research Department which had the following functions:

1. To lay out boundaries of dealers' territories along scientific lines and review contracts negotiated by the sales department.
2. To gather statistics bearing on the markets in which the company buys and sells.
3. To predetermine what the sales performance should be for the market as a whole and for each dealership.
4. To figure quotas and schedules for the market as a whole and for each dealership.
5. To keep statistical records of dealers, subdealers, and salesman's performance.
6. To analyze sales performance and point out faults and remedies.
7. To forecast economic conditions in markets in which the company buys and sells.
8. To analyze, construct, or carry out routines and sales promotion plans, investigate methods, practices, and policies.

This department carried out considerable research in all of the fields outlined, experimented with methods of establishing and varying quota, and fixed standards of performance for dealers upon the basis of economic studies. Much of the work done along these lines was, of necessity, fundamental in character, but a practical application of current results was necessary during the entire existence of the department. The work of this particular department has been greatly curtailed during recent months, but during the period of its chief activity a few sound major principles were established, which constitute probably the results of the most fundamental market research that has been done directly applied to passenger car marketing.

Territorial analysis has been attempted by a few companies, but the work has related to particular cars and to particular periods rather than to the establishment of and fundamental principles of general procedure. In many cases the study of markets is carried only far enough to permit the establishment of some sort of temporary working basis upon which to proceed for a few months to come.

Scientific studies of distribution costs have not played any important part in passenger car marketing studies thus far, while investigations concerning buying habits and buying characteristics have been sporadic and inconclusive in nature.

A brief survey of methods of setting quota in representative passenger car firms gives a clear picture of what studies are being conducted along these lines.

Very elaborate market analysis work precedes the establishing of quota in one or two cases. Comprehensive and accurate data are collected concerning a large number of factors affecting sales possibilities. These data

are listed, a certain weight is given to each of the factors and the factors are correlated to give the quota for the given territory.

One successful, conservative organization establishes distributor quota in this way:

THE percentage of registrations in a given territory to the total car registrations is first determined. The factory then determines the percentage of its own production absorbed by that territory during the previous year. When these percentages are about the same, as they are in many cases, the distributor is allotted that percentage of the year's production. When the two percentages do not agree, however, a compromise percentage is given, arbitrarily fixed with due regard to conditions within the territory, the number of cars that the distributor himself believes he can sell, road conditions and other factors.

In one factory quotas are established by taking the actual number of cars sold by a given distributor last year and adding to that number "as many more as the factory thinks he can handle in view of his selling ability and conditions within his territory." The number of cars to be produced by the factory, however, is determined before these quotas are established, so that the sum of the distributor's quota must arbitrarily be brought to that predetermined production total.

In another case, the distributor is expected to take a number of cars equal to a given percentage of sales of competitive makes to the total sales of the competitive group in his territory during the preceding year.

Another factory practically allows the distributor to say how many cars he will take.

Still another bases its quotas upon the number of cars taken last year by the given distributor, plus a certain number which is determined in conference with the distributor.

One company sets its production schedule and then gives to each distributor a proportion of that predetermined number based on the percentage of production absorbed by that distributor during the previous year.

One successful manufacturer likewise bases quota on the percentage of past production taken by the given distributor. Production is based upon "a number of factors compiled by the statistical department."

Another company relies very largely upon the intimate personal knowledge of the field possessed by a capable sales manager, correlated with the past performance of the distributor and the opinion of the district sales manager.

Still another method is found in basing quota upon the percentage of the given make of cars sold in the territory as related to total sales during the previous year plus a certain per cent.

AUTOMOTIVE INDUSTRIES has been conducting some general studies in connection with passenger car market limitations and probabilities, the results of which have been published in current issues. The whole field of research has not been adequately mapped out, however, nor has sufficient attention been given to correlating the various minor activities that are being carried on along this line.

The field of passenger car market research may be divided broadly into eight general divisions, as follows:

1. Size of market numerically.
2. Size of market in dollars.
3. Buying values—factors affecting buying.
4. Selling costs.
5. Selling methods.
6. Distribution methods.
7. Economic and human factors affecting buying.
8. Relation of service to sales.

Probably more effort has been made to determine the numerical size of the market than to analyze any of the other factors mentioned. Many of these studies have been static in nature, however, considering conditions only as of a given date. This has made it difficult to deduce from them any general principles. Research will seek to determine such principles so that methods of procedure for the future can be laid out on the same basis, even though current conditions fluctuate.

The numerical studies that have appeared in AUTOMOTIVE INDUSTRIES are good examples of the type of research activities needed along this line. These studies have viewed the numerical size of the market on a dynamic and constantly changing basis, seeking to establish methods and fundamentals which, through the interpretation of trends, will make it possible to determine the immediate future at any given time with a reasonable degree of accuracy.

Studies of this kind will first have to do with the prospective market for passenger cars in general. Then divisions into price classes and studies on the basis of price-class divisions will be necessary. For all work of this type, the free exchange of ideas and information among the various interested organizations is likely to prove of benefit to all concerned. So little has actually been done and so few fundamentals have been established that there is a rather strong necessity for an exchange of what data is available and a joint consideration of the factors involved.

Individual companies will later be able to analyze their own position and prospects in relation to others in their price group on the basis of the principles established through the more general studies just mentioned.

Research as regards the financial size of the market will naturally follow somewhat the same lines as those having to do with the numerical size, as one is dependent upon the other. The problem here is one of translation rather than of separate study.

THERE have been many statements made and many opinions expressed about buying values—about what the public wants. But there has been comparatively little investigation to find out. Buying values change, moreover, as do all the other factors affecting passenger car sales. New bases of comparisons arise and new influences determine in the mind of the purchaser the type and kind of car which he will buy. The continuous problem of every passenger car manufacturer is to correlate the design and equipment of his car with these comparatively unknown desires held by the public.

The abstract nature of this problem renders its solution doubly difficult and the necessity for pure research doubly urgent.

MARKET research in the passenger car field will accomplish many practical things for the manufacturers. Some of these are:

Predict with reasonable accuracy the probable market for cars.

Show the factors which influence buyers most strongly.

Bring to light inefficiencies in selling and distribution methods.

Stabilize production and reduce overhead.

Show in detail how service can be made a more effective aid to sales.

The cost of selling automotive products has constantly risen during the last ten years. This increased sales cost has been absorbed thus far by the increased efficiency of production processes. The relative efficiency of sales from a cost standpoint has decreased rather than increased. This process cannot go on indefinitely, and the period has arrived when a closer study of marketing costs is essential.

A high executive of one of the largest automobile companies is operating an important branch as an experimental laboratory for research in connection with retail selling methods. The results of the experimental work done in this branch is then correlated and transmitted in practical form for the use of all the distributors of the organization. This experimental work has been under way for some time. More studies of this type among manufacturers would be advantageous.

Selling methods may be considered largely a problem of the dealer, yet the manufacturer is so intimately dependent upon dealer efficiency that he must necessarily pay a certain amount of attention to selling methods. Certainly, the manufacturer will have to do whatever research work is accomplished along these lines.

MORE study has been given to distribution methods during the last twelve months than ever before in the automotive industry. The channels of distribution for passenger cars grew up like Topsy without any scientific analysis of the probable development nor the economic necessities of the situation. Only twenty years ago manufacturers were arguing as to whether or not "agents" would be necessary or whether the practice of buyers coming to the factory for cars could be continued indefinitely. To-day there are more than 30,000 dealers engaged in the business of selling passenger cars in the United States.

Between the manufacturer and the dealer the distributor or the factory branch has an economic function in the distribution system. The exact function and relationship of each of these distribution units has not yet been accurately defined, and readjustments are taking place all along the line. Considerable scientific study of the problems involved will be necessary before the most efficient system is determined.

The matter of storing cars, dealer inventories and the possible relation of the public warehouse to economic distribution all are a part of the factors concerning which further research is necessary.

FUNDAMENTALLY the human element is at the bottom of all car sales both from a selling and a buying standpoint. The variables affecting the human factor have been studied only superficially up to the present time and considerable effort will be necessary in this field of research. Effective work is already being done in a number of places as regards a study of business cycles and economic trends as affecting passenger car marketing.

The relation of sales to service is now generally recognized as important, but further study will determine more accurately the details of that relationship and thus enable manufacturers to better adapt design to the needs of the user and so order service methods that service will be a real asset to the sales department.

Magnesium Piston on New French Racer

FIRST of the new French 122-cu.-in. racing cars to get on the road are the Rolland-Pilains, built at Tours. These cars had been intended to start in the Indianapolis 500-mile race, but owing to delays at the factory they could not be completed in time for the trip across the Atlantic. They will appear in the French and Italian Grand Prix races.

The Rolland-Pilain engines have eight 2.32 x 3.54-in. cylinders in one aluminum casting, with a thin steel liner. Two valves per cylinder are used and they are mounted in the head, the angle between them being 160 deg. There is a separate camshaft for each line of valves, with front end drive by a train of spur pinions. A single spark plug is mounted in the head and receives its current from a Delco generator. Ball bearings are used for the crankshaft, camshafts and timing gear, and roller bearings for the connecting rods. By the use of magnesium the weight of the pistons has been got down to 0.22 lb., compared with 0.46 lb. for pistons of similar design in aluminum. The piston pin floats and has no bushings.

Experiments have been carried out with a mechanism for positively closing the valves by cam action, but it is not known whether this will be used in the race or not. At the present time both this system and the normal system of closing by valve springs are prepared, for two separate sets of cylinder heads have been constructed, and it will depend on the tests which type is finally retained.

The engine is combined with the gearbox, this latter providing four speeds ahead and reverse. Drive is transmitted through the springs, with torque reaction provided for through the gearbox; there is thus a single universal joint. The clutch is of the plate type and is fully enclosed.

The Rolland-Pilain racing car, the design of which is based on research work

In the chassis layout the features are the underslinging of all of the springs and of the frame at the rear. This gives the car a general slope rearward, and keeps the center of gravity down very low. As the French Grand Prix race is run on a course only 8 miles round, it has been decided to abandon the use of a spare wheel. This has enabled the body lines to be refined and has tended somewhat toward reduction of weight. With a track of 47 in. in front and 43 in. at the rear, and a wheelbase of 110 in., the total weight of the car is 1455 lb. This is 66 lb. above the minimum imposed under the French racing rules. The Rolland-Pilain cars are fitted with hydraulically operated front wheel brakes and hand-operated rear wheel brakes. The brake drums are in the axis of the wheel and steering pivots are straight.

Drivers of these cars in the European races will be Albert Guyot, Victor Hemey, Louis Wagner, and the aviator, Sadi-Lecointe.

Market Research Increases Motor Truck Sales

Past sales figures are carefully studied. Factors affecting demand constitute vital problems. Better correlation between production schedules and territorial quotas is sought. Sporadic sales analysis being done by almost all manufacturers.

By Philip H. Smith

MOTOR truck manufacturers are studying facts and figures concerning their actual sales far more thoroughly than they are analyzing market probabilities and demand and the factors affecting this demand.

A survey of the industry shows that market analysis is not playing an important part in the setting of production schedules.

Most frequently the method employed is for the sales manager and production manager or other executives to get together and set a production schedule based on their judgment of what they think they can dispose of through their selling organization. Territorial sales quotas must then conform to the factory schedule.

One concern sets production schedules by weighing the reports of the district managers. Another bases it on previous sales in the various localities using, to some extent, truck registration figures to determine strength of competition. In the case of bringing out a new model with no previous sales record to go by, they secure all possible production and sales figures of competing concerns and attempt to determine the actual demand for that particular model. Here again registration figures are employed. As a tempering factor the business conditions in the various territories are weighed against past sales performance. This latter concern has done rather exceptional analysis work.

The accuracy of the final conclusion as to actual demand depends chiefly on the ability of the branch manager or distributor to analyze his own specific territory.

Some study of markets is being carried on. Several concerns have carried investigation to great lengths and over a period of years, not always with satisfactory results. The method of adjusting territorial sales quotas is much the same as that used in setting production schedules. For the most part they are based on previous sales performance and to that is added what the sales managers think they can do in the coming months or year in the way of improvement. Often there must be more adjustment to fit a pre-determined production schedule. In short, the decision is left largely to the sales managers or manager and then adjustment is made with production.

Some of the results of this policy are: Overloading the selling organization because of the necessity of absorbing over-production; too many trucks in one territory and not enough in another with consequent losses and added expense from re-allocation.

Study to determine the best markets consists largely of analysis of past sales performance and conclusions drawn roughly that the best territory is necessarily that in which the most trucks have been sold. This method neglects the factor of actual demand and makes no allowance for the varying rate of growth in different territories.

Probably the strongest division in markets is that which exists between rural and urban. Manufacturers of heavy units have thus far found the urban markets to be the best for their product, while the manufacturer of light units finds the rural market a prolific one. The investment in the heavy duty truck is so large as a rule, as to necessitate maximum use to be profitable. This again makes evident the necessity of selling transportation rather than a particular type of truck.

The manufacturer of heavy duty trucks is beginning to concentrate on the branch form of selling organization with the object of controlling sales and service. The manufacturers of light trucks (which often use a passenger car engine) spread their selling effort over a wider territory and are not able to confine their selling to branches. We may say that the selling of light units is both intensive and extensive within an area, while the sales of heavy units is becoming increasingly intensive in the larger cities within the same area.

One concern states that they depend exclusively on branches for their business and have only a few dealers. The amount of business secured by the dealers is so small that they do not consider them in setting sales quotas. They maintain that they have found the giving of service so important that they cannot afford to let the responsibility rest outside the concern.

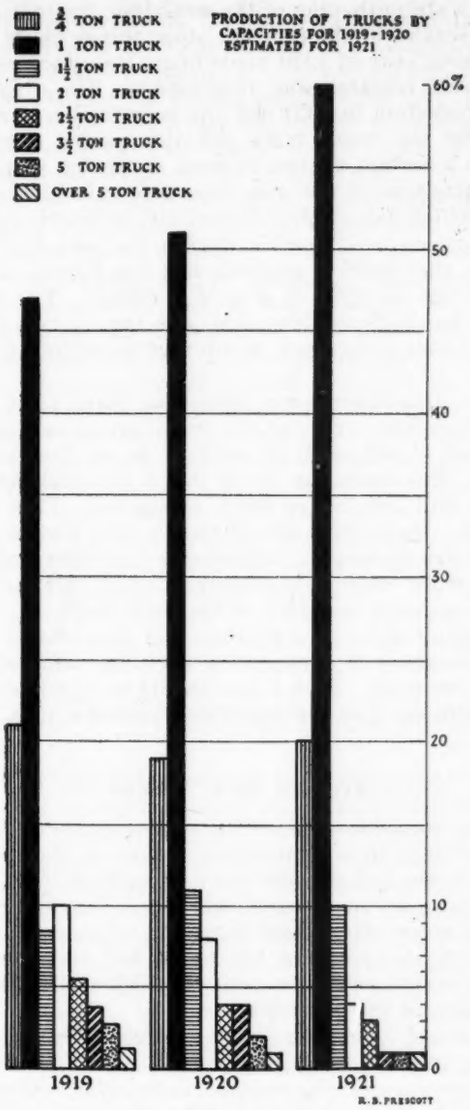
Manufacturers who distribute their product through a distributor-dealer organization find themselves handicapped in securing sales data in that the necessary cooperation in this matter is sometimes hard to obtain.

In the majority of cases the conclusions reached regarding the best form of organization and markets has been one of trial and error. Markets have been picked on the strength of past sales performance and very little by

"THE truck business is just beginning. The next five years after this should be the greatest period in the history of the industry.

"Our population is growing at the rate of 1,000,000 yearly. Our mode of living is constantly expanding, with the resultant increased demand for commodities of every description.

"We have 2,133,000 miles of highways and only 266,000 miles of railroads."



analysis of business conditions in the different districts.

With the exception of collecting data to assist the selling organization in studying a prospect's transportation needs, manufacturers have done comparatively little research work in connection with selling in the field and dealing with the ultimate sale to the consumer. Most companies leave this strictly to the direct representative.

There exists a wide divergence in the attitude of manufacturers toward this field of market analysis. One states that they are not opposed to it but just have not done any, believing that their business is so satisfactory that there is no particular need for study.

Another manufacturer believes that the added cost of employing people to carry on market analysis is not justified by the returns. In this case any analysis work that is carried on is done by the branches as they see fit and covers only the specific branch territories. The reason given is that it is difficult to convince a branch manager that the factory can know anything about his territory that he does not already know. It is assumed that a manager who is capable of appreciating the value of this kind of study is capable of carrying it on for himself.

Manufacturers have done, and are doing, a lot of valuable work in furnishing specific data to assist representatives in selling transportation to their prospects. Information is given regarding competitive trucks, the transportation needs of different industries, engineering features and principles as well as other material aimed to develop greater ability in the salesmen. Some factories have field representatives who are constantly giving assistance over the entire territory covered. Others utilize vocational files, field research and transportation engineering bulletins. Several concerns are training salesmen to become specialists in the transportation needs.

Territorial Sales Competition

In one instance a factory branch has done some very satisfactory work in determining the strength and nature of competition in its territory. This work has been carried along consistently for several years with increasing benefit. The factory is now undertaking a similar study of competition in all territories which will serve both factory and selling organization in helping to find the company's particular position in the industry.

Not the least benefit from this work is that of furnishing the means whereby the individual selling organizations may check up their own sales performance and the factory can check up on branches or distributors.

Used trucks have come to the fore as a problem. Many concerns have stated that it is the severest of all problems with which they have to contend. As yet very little study has been given to it and that of a widely divergent nature.

One factory which employs the policy of refusing to permit trade-ins of any trucks other than its own product has been able to avoid many of the troubles of over-allowances. This policy cuts down sales considerably and probably could not be carried on without there being a great number of existing owners, something a newer concern would not have. It is important to note that this concern rebuilds its "trade-ins" and wisely takes into account the number of rebuilt trucks on hand in a particular territory when setting sales quotas for that locality.

Another manufacturer has made a study of the potential replacement market for trucks by attempting to determine the average length of life of a truck. This has not proved very successful as yet, but he hopes by keeping at it to obtain concrete facts to work on.

Making Territorial Boundaries

The factor of the effect of distance in the cost of marketing has received very little attention. True, changes have been made which prove a recognition of the importance of this factor, but they have not, for the most part, been the results of any careful research.

The question of the maximum radius over which it pays to operate, which radius varies according to local territorial conditions and competition, resolves itself in the main into two parts:

1. The radius over which a branch or distributor may operate before increased economies would result from additional branches or distributors.
2. The most economical radius over which a dealer may operate. Whether additional dealers should be appointed or the number reduced.

"THE U. S. Committee on Reconstruction and Production has estimated this year's motor truck tonnage at 1,430,000,000 tons, and this is very likely to be more than one-half of the railway freight tonnage.

"So from this fact about the increased movement of goods, the prospects of the motor truck industry for the year are particularly bright."

Of the different factors bearing on the most efficient area to be covered by any one organization; actual demand within the territory, ability to make personal contacts, freight rates and ability to render proper service, the latter is now, perhaps, the most deciding factor in marketing motor trucks.

How to Analyze Markets

An efficient, accurate production program cannot be set without some knowledge of potential and actual demand. It can be approximated in many cases but no amount of confidence in the superiority of "our product" or the collective judgment of executives can take the place of a scientific study of actual demand.

Manufacturers should first sell transportation and evidence the rendering of real service before undertaking market analysis, because business which has been secured without consideration of fitting transportation needs is not a good criterion of future business.

A knowledge of business cycles is of primary importance. Market research will be incomplete and inaccurate unless the existing phase of the business cycle is known and applied to the data at hand. This means that we must know whether we are on the down grade or up grade of business activity.

The following steps are suggested for setting a scientifically determined production schedule:

1. Actual production figures of the specific concern taken over a period of years and the ratio of its production to the total production determined for each year. This will show what percentage of the total business has been secured and whether the percentage is normal, increasing or decreasing with relation to the total truck production.
2. Having determined the proportion of business which may logically be expected, the figure must be weighed against the existing phase of the general business cycle which will give the actual demand. The actual demand should be the production schedule.

The next steps in the procedure are:

3. An analysis of the nature of the transportation requirements of the concerns within a specific territory to determine the potential demand which the manufacturer's product is suited to fill.
   (a) An analysis of business conditions within the territory and application of this analysis to this demand. This will give the actual demand in the territory.
4. An analysis of past sales performance (over a period of years as in No. 1) of the specific manufacturer in that territory with relation to the performance of all competitors, in other words, the percentage of total business secured by the specific manufacturer. This will give the actual demand for that manufacturer's product (with seasonal variation) in the specific territory.

The production schedule is then determined by taking the sum of these actual demands in all territories covered.

The production schedule determined by No. 1 and No. 2 should be the same as that determined by No. 2 and No. 3. This serves as a check on the work done.

In two instances it was stated that past performance should be considered over a period of years rather than for just one year. This is essential because a manufacturer may be increasing the number of sales in a specific territory, or increasing production, and yet be falling behind with relation to his competitors and the industry as a whole. Territorial analysis and analysis of production figures will show up these facts. If sales are decreasing with respect to the whole industry they cannot be increased without a strengthening of the weak link, the selling organization, service or the product, other things being equal.

The boom year of 1920 made many manufacturers think that market research was unnecessary. The great falling off in production in 1921 and the very trying, bewildering times that the motor truck industry passed through, revived, to a certain degree, interest in market research but at the same time it was also necessary to curtail all expenditures which did not give immediate, profitable returns.

The concensus of opinion during the period of depression was that market research had not proved its worth, hence it was no time to give it a tryout. The study of markets has suffered from the idea that it is not needed in boom times and cannot be afforded in periods of depression.

Before undertaking any analytical work it is wise to make a complete survey of the organization and determine with what object analysis work is to be done and what facilities they have for doing it. A comprehensive plan must be laid out before work is started. This is often neglected. Data are collected before it is known to what use they are to be put. Sometimes the right material is secured, more often it is not right, or at best incomplete, and this prevents accuracy of the final result.

The laying down of a fundamental plan should be done by an executive in conjunction with the man who is to carry on the work. Such a plan should be as comprehensive and specific as possible and follow definite lines of procedure.

Trained Men Needed

Failure to achieve anything through market analysis and inaccuracy in such work as is done is due in a large measure to the lack of sufficient data to work with.

The desire to do research work has been promoted by necessity more often than foresight. Consequently data from previous years are not to be had and conclusions must be secured promptly, both of which spell a limitation in the value of the work done.

Data should be collected over a period of years. There are many variable factors, and the only way that the percentage of error can be reduced is to cover a long period of time. Analysis work cannot be promoted without the recording and analyzing of business experience and this cannot be done without recording it as it occurs.

Some difficulties have been experienced by manufacturers who produce both trucks and passenger cars in that they have not realized, in their research work, that the factors which govern the sale of trucks are totally different from those which govern the sale of passenger cars.

It is difficult to acquire men trained in the carrying on of market research because it is a comparatively new field of study. Statisticians or men with an analytical type of mind have been chosen in some cases. As a rule, anybody that liked to fool with figures has been eligible. A wide knowledge and grasp of general business principles, however, is essential.

The effectiveness of sales analysis depends on the ability with which the sales manager translates the information to the selling organization. The facts must be disseminated effectively. There exists a wide difference in the capabilities of sales managers to use the material which is furnished them.

The men who conduct and utilize market research must be granted the same status and consideration as is given to those engaged in engineering research, and if they are not worthy of this consideration then they are not the men to carry on successful market research for a concern.

The field of truck transportation is enlarging steadily, and with it come new needs for analysis. Bus transporta-

tion affords an outlet for truck production that is constantly growing in importance. The installation of bus lines on a sound financial basis requires a study of operating costs which the truck manufacturer can, and should, assist in. Manufacturers might well study the transportation needs of territories and be ready with assistance for those who undertake to install bus lines.

The larger conception of the economic value of highways will bring about many changes which must be foreseen. As one manufacturer puts it, "I expect to see a revolution of our conception of the highways, which in turn will change the character of the truck industry materially."

New legislation with regard to truck loads, sizes and widths means that the truck manufacturer must be constantly studying transportation requirements with relation to these laws of limitation, for such they are.

Already there exists divergence in opinion between truck manufacturers as to the type of transportation unit which will ultimately have to be used to carry the necessary loads and remain within the law's requirements. One says that it will force heavy loads to be carried on six wheels, another says that it will increase the number of smaller trucks and do away with the big units.

That railcars are yet in their infancy and research work will probably be limited to engineering for some time is the general opinion. Far-seeing manufacturers will begin to study the potential market for this type of vehicle before the necessity arises.

Co-operation with the railroads in the transportation of commodities has become extremely necessary. Some manufacturers have undertaken a study of this, but the majority consider it something to be done by truck operators and railroads and quite beyond their field of endeavor.

A survey of the industry shows several reasons why market research may have failed to give satisfactory results in the past. Some of the difficulties which almost all manufacturers have had to contend with can be listed in four groups as follows:

1. Lack of knowledge of what market research is and what it is capable of doing.
2. Absence of a fundamental, well thought-out plan of procedure.
3. Insufficient data with which to carry on work.
4. Lack of properly trained men to carry on research.

Reactions of Accelerators During Vulcanization

C. W. BEDFORD and L. B. Sibrell presented a paper on the above subject to the Rubber Division of the American Chemical Society at its Rochester (N. Y.) meeting in April last. The authors regret the lack of knowledge concerning the chemistry of sulphur reactions of organic nitrogen compounds. They attribute the curing power of nitroso accelerators first to their oxidizing power, which will greatly speed the reaction of the sulphur with the accelerator rubber resin or rubber protein, thereby bringing the nitrogen in the rubber into quicker action as an accelerator. In this sense, therefore, nitroso accelerators are, first of all, secondary accelerators acting in the same manner as litharge. Nitroso phenol has this type of accelerating power, and the fact that its reduction product is not a primary accelerator has no bearing on its action as a secondary accelerator.

The carbosulphydryl accelerators constitute the most important class of vulcanization aids known to-day. This carbonide is probably used in larger tonnage than the gross weight of all other accelerators together. Other than thio-urea derivatives, this class includes the thiuramins, dithiocarbonates, mercaptans, mercaptides, disulphides and all accelerators which produce these or similar compounds during the vulcanization process. In considering the class as a whole, one cannot overlook the great effect that zinc oxide has on the curing power of these accelerators, and it soon becomes evident that the action of the secondary accelerator must be known before much can be done to explain the action of the primary accelerator.

The question of the use of organic accelerators was discussed at a recent meeting of the Institution of the Rubber Industry at London, and considerable difference of opinion developed. Dr. Henry P. Stevens, the speaker of the meeting, favored the use of accelerators. He considered the use of a very slight proportion (about 1:800) of sodium bisulphide as quite harmless. The bisulphide is added to the rubber to prevent the development of an inorganic ferment which darkens the rubber and subsequently turns it streaky. The bisulphide is a preventative, not a cure, and if the darkening has once set in it cannot be cured even by concentrated solutions of bisulphide.

Reagents for Etching Alloy Steel

SOME experiments in the line of sequence etchings have been carried out at the Bureau of Standards at Washington on specimens of high speed steel in the condition as "received from the mill." Sequence etching means the etching with two or three reagents in successive order without any repolishing of the section between the etchings, and the taking of photomicrographs after each etching at the same spot in the microsection in order to note any changes in microstructure produced by the last etching as compared with that developed by the preceding etching reagent.

The reagents used in various combinations were: (1) Dilute ammonium hydroxide solution together with a weak electric current, the specimen being made positive pole; (2) two per cent alcoholic solution of nitric acid; (3) boiling sodium picrate, and (4) Murakami's reagent (solution of potassium ferricyanide and sodium hydroxide) at boiling temperature.

The results, as judged from the behavior toward the various etching reagents tried, appear to show that there are at least three different constituents present among the imbedded globules or particles in the specimen of high-speed steel, in the "as received from the mill condition," though any attempt to state the nature of these constituents would, in view of present developments, involve speculation.

Market Research Essential to Development of Tractor Design

Farming methods not likely to be changed to meet tractor requirements. Tractor must meet farm needs. It is essentially a power generator for soil preparation and belt work. Government and agricultural schools active in tractor research.

By E. A. White

THE year 1913 is generally regarded as a turning point in the tractor industry. It marks the time when manufacturers turned their attention to developing the types of machines which have constituted the large bulk of the sales during the past eight years. Now the question arises as to what ultimate market the types recognized as standard today will find, and whether or not it is necessary, to supplement these types with others in order to realize the maximum benefits of the internal combustion engine in agriculture and industry. The tractor manufacturer has or should have his eye on a world market. No matter by what means the directors of the industry's policies arrive at their conclusions they are certain to formulate plans in regard to the domestic and foreign market for the tractor. Whatever the policy, it will take into account both the active and potential markets. As so much depends upon the conclusions arrived at in regard to these matters it is important that the foundation upon which they are based should be as broad, deep and as substantial as possible. In the present state of tractor development and use we cannot know too much regarding the power requirements of agriculture and industry together with the results which have been attained with the present types of tractors in these fields.

At best it is a complicated problem involving many interrelated factors which must be differentiated, weighed and placed in proper relation to each other. In fact the problem is so complicated that most tractor manufacturers have used what might be called "a wholesale integration" method of arriving at conclusions. The sales department is consulted and the sales manager gets opinions and other information from the force in the field. Similar material is collected from the design and service departments and from this the policy is formulated. There is no denying that this system has its value and will always be used. The point is: Can it be supplemented by investigations and researches which will throw light on the problem yielding results commensurate with the expense involved?

As "the proof of the pudding is in the eating" this question can only be answered by finding out what light can be thrown on the market possibilities of the tractor from the investigations and researches which have been and are being conducted by various institutions and organizations. It is the purpose of this article to call attention to the more important sources of information and by means of a few examples show some of the possibilities in this direction.

In U. S. Department of Agriculture Circular 212 there is given tractor production statistics for the years 1909 to 1920, inclusive. The U. S. Department of Commerce, Bureau of Census is now collecting the production statistics for the year 1921, but the information is not yet available. The Statistical Number of AUTOMOTIVE INDUSTRIES estimated this at 50,000. Taking the information from the above sources it is found that 704,906 tractors have been produced in this country during the years 1909-1920, inclusive. During the years 1916-1920, inclusive, the tractor production was 592,906 or approximately 83 per cent of the total as given above. Of the 1916-1920 production 472,943, approximately 80 per cent, were sold in this country. It is too early to be able to report any figures regarding 1922 tractor business, but sufficient information is at hand to warrant the assertion that more tractors have already been sold this year than during the entire year of 1921.

The American farm has been the chief market for tractors and undoubtedly will continue to hold premier position in this regard. The 1920 census showed 246,083 tractors on farms. With this as a basis it is estimated that there were 396,071 tractors on American farms Jan. 1, 1922, according to the method shown in Table II. This gives an increase of 61 per cent in two years, a remarkable showing when the conditions prevailing during the last half of 1920 and during the year 1921 are taken into account.

Only 3.6 per cent of farms, however, reported tractors on Jan. 1, 1920. The sale of tractors during the past two years probably raises this figure to between 5 and 6 per cent. These figures leave no doubt that as far as number of farms is concerned there is a remarkably large potential market for tractors.

The problem is: What percentage of this potential market will become active and how fast will this transition take place? In this con-

TABLE 1

TRACTOR PRODUCTION BY YEARS

Data, except for 1921, from U. S. Department of Agriculture, circular 212.

Year	Tractor Production
1909	2,000
1910	4,000
1911	7,000
1912	11,000
1913	7,000
1914	10,000
1915	21,000
1916	29,670
1917	62,742
1918	132,697
1919	164,590
1920	203,207
1921	50,000
Total	704,906

nection it is well to look at the number of farms classified according to size. Of the total number of farms 4,428,107, approximately two-thirds, are between 20 and 174 acres in size. There are 1,223,701 farms over 175 acres in size. These larger farms constituting something less than one-third the total number of farms furnish a most attractive tractor market, but it is evident that if the possibilities of power farming are to be realized the other two-thirds must come in for careful consideration.

The tendency in tractor development today is to give more attention to the small farm on the hypothesis that it is easier to build a tractor to meet its power requirements than to attempt to change the system of farming to meet the power possibilities of the large tractor, which is much too expensive for the average farm.

For the past ten years the tendency has been to develop smaller and smaller tractors, and on the basis of the total number sold these smaller tractors have found a relatively large sale. In 1920 the last year for which definite information is available on this point 98,735 of the 162,988 sold to dealers in the United States had a rating of 18 horsepower or less on the belt, undoubtedly placing them in the 2-plow or smaller class.

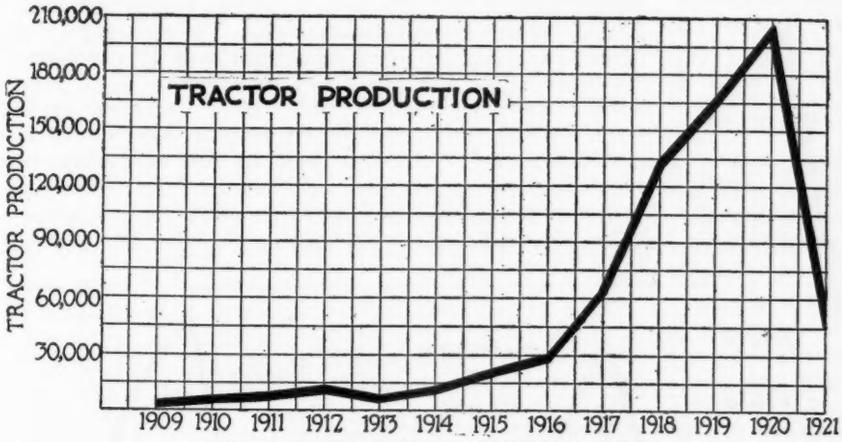


Fig. 1—Tractor production 1909-1921 inclusive

It would be of interest and value to know on what sizes of farms tractors have been placed. A company manufacturing a representative line of tractors, including 2- and 3-plow models, made a field survey in 1920 of a large number of the purchasers of these sizes of tractors and the results showed that 80 per cent of them had gone to farms over 175 acres in size. In other words, on the basis of number of farms this company was selling over 80 per cent of its products to 20 per cent of the market. Unfortunately the Bureau of Census did not classify tractors on the basis of the sizes of farms. A number of surveys have been made, however, both by the U. S. Department of Agriculture and a number of agricultural colleges in which the sizes of farms on which tractors are used are given.

What these investigations show on this point is well illustrated by the results of three investigations conducted during the past year and one-half by the U. S. Department of Agriculture in three different sections of the country. H. R. Tolley, who had direct charge of the field work, expresses the belief that the results obtained are entirely typical of the distribution of tractors on the farms of the regions where the investigations were conducted.

The southern investigation covered 684 farms on which tractors are owned in the States of Alabama, Georgia, North Carolina, South Carolina and Tennessee; the corn belt investigations covered 286 farms in the States of

TABLE 2

Method of estimating the number of tractors on American farms Jan 1, 1922; the number is 71 per cent greater than Jan. 1, 1920.

Tractors on farms, Jan. 1, 1920 (U. S. census)	246,083
Tractors sold to dealers, 1920 (U. S. D. A. manufacturers census)	162,988
Tractors manufactured 1921 (estimated)	50,000
	459,071
On hand, dealers and manufacturers, Jan. 1, 1922 (estimated)	40,000
Sold to others than farmers during 1920 and 1921, including 1921 exports (estimated)	15,000
Discarded (80% 1914 production)	8,000
	63,000
Tractors on farms, Jan. 1, 1922	396,071

TABLE 3

Ford Tractor Sales by States, to Dealers

1917-18—Jan. 1, 1922

	Total		Total		Total
Alabama	945	Michigan	5,075	South Dakota	2,993
Arizona	523	Minnesota	6,838	Tennessee	2,072
Arkansas	1,663	Mississippi	868	Texas	9,909
California	9,008	Missouri	5,543	Utah	756
Colorado	2,681	Montana	1,356	Vermont	454
Connecticut	467	Nebraska	5,174	Virginia	2,724
Delaware	354	Nevada	40	Washington	2,388
Florida	1,166	New Hampshire	246	West Virginia	939
Georgia	2,852	New Jersey	1,768	Wisconsin	6,532
Idaho	1,000	New Mexico	367	Wyoming	589
Illinois	13,993	New York	6,306		
Indiana	8,081	North Carolina	3,246	Sub-total	162,296
Iowa	8,981	North Dakota	3,265		
Kansas	8,615	Ohio	10,585	Alaska	7
Kentucky	1,892	Oklahoma	4,827	District of Columbia	65
Louisiana	2,197	Oregon	2,385	Hawaiian Islands	49
Maine	675	Pennsylvania	6,036	Mexico	328
Maryland	1,431	Rhode Island	134		
Massachusetts	951	South Carolina	1,406	Grand total	162,745

TABLE 4

Showing the percentage of horse-hours for various operations according to investigations conducted by the U. S. Department of Agriculture and reported in 1919 year book.

Operation	Iowa grain and stock farm	Illinois corn and hog farm	Wisconsin dairy farm
Road hauling	26	20	13
Farm hauling	21	22	35
Plowing	3	16	11
Discing	8	12	8
Harrowing	6	4	5
Rolling	..	4	1
Cultivating corn	12	11	6
Cutting grain	2	1	2
Hauling manure	9	4	8
Other work	13	6	11
Per cent total work	..	..	..
Two-horse operations	65	57	58

TABLE 5

The total days which the tractor was used on the farm and the distribution of the work for which it was used.

	Southern	Corn Belt	Wheat Belt
Total days used per year	52.5	30.8	37.6
Per cent home work	93.0	85.0	87.4
Per cent custom work	7.0	15.0	12.6
Per cent home work plowing	44.0	47.5	....
Per cent home work other drawbar work	36.0	42.4	....
Per cent home work outwork	20.0	12.1	8.0

Illinois, Indiana and Ohio and the investigation in the spring wheat belt covered 354 farms in the States of Oklahoma, Kansas and Nebraska. In commenting on this Mr. Tolley said: "In any community you find relatively few tractors on farms under the average size of farms in that community."

The distribution of tractors by sizes of farms as found by these investigations and the distribution of farms by sizes in the states listed above are plotted in Figs. 2 to 7, inclusive. Unfortunately the reports of the investigations were not compiled according to the sizes of farms as reported by the Bureau of Census. These charts show that there is a distinct correlation between the larger farms and the number of tractors, and bear out the contention that the smaller farms have not yet been motorized to any appreciable extent. This would also lead to the conclusion that at present greater results can be secured by directing sales efforts towards the larger farms. The conclusions regarding future developments are left for the reader to formulate.

So far as is known there are no comprehensive investigations reported making an analysis of the horsepower hours required for various farm operations in different types of farming. Lacking specific information the best course is to make use of such material along this line as is available. In the 1919 yearbook of the U. S. Department of Agriculture there is a report of an investigation of the horse-hours required for various operations on three farms. A summary of this report is presented in Table IV which gives the percentage of horse-hours required for the more important operations. The percentage reported for plowing on the Iowa farm is low because the fall plowing was done with a tractor which had been purchased primarily for belt work. While the figures in this table do not represent accurately the relative amounts of power required for various operations they are accurate enough to indicate what problems must be met. Perhaps the most surprising fact is the large amount of 2-horse work due in no small measure to the large amount of farm and road hauling.

Such figures as these raise the question of how large a percentage of farm work can be economically done with a mechanical motor having a larger working capacity than a 2-horse team. Upon the answer to this question depends, in no small measure, the ultimate types of tractors. It should be pointed out that generating power for belt work was not taken into consideration in this investigation. Therefore the total farm power requirements are greater than indicated by the reports.

After studying the farm power requirements it is important to find out how completely farmers are using tractors. Some idea of this can be gathered from the results reported in Table V which are taken from the reports of the three investigations conducted by the U. S. Department of Agriculture previously referred to. In comparing this with the data in Table IV it is found that plowing which constitutes less than 20 per cent of the farm power requirements represents over 40 per cent of the tractor use and other soil preparation work makes up a large percentage of the balance exclusive of belt work. While the U. S. Department of Agriculture has reported some 17 drawbar and 15 belt operations for which the tractor has been used on the farm, all reports examined in the preparation of this article clearly indicate that in the field to-day the tractor is essentially a power

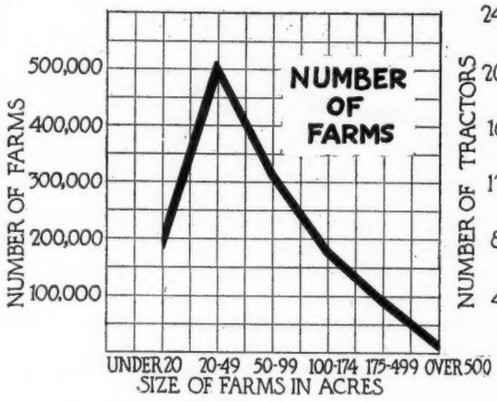


Fig. 2—Distribution of southern farms by size

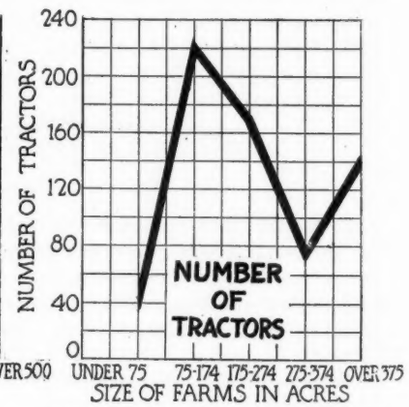


Fig. 3—Distribution of tractors on southern farms

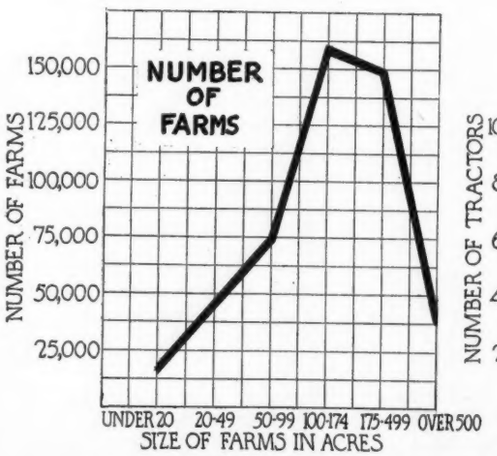


Fig. 4—Distribution of winter wheat belt farms by size

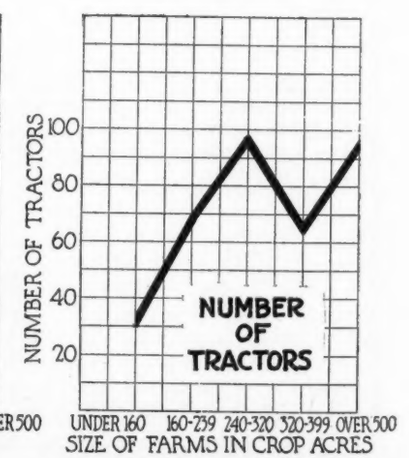


Fig. 5—Distribution of tractors on winter wheat belt farms by sizes of farms

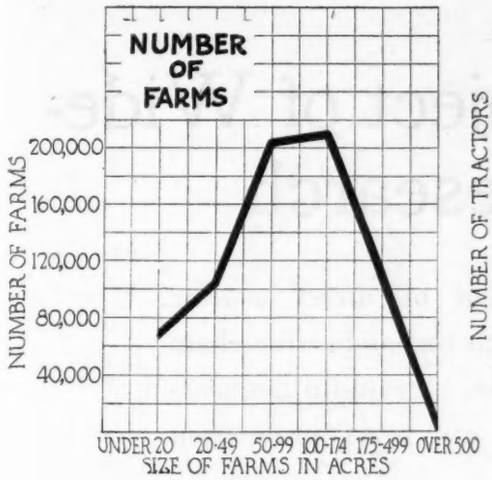


Fig. 6—Distribution of corn belt farms by sizes

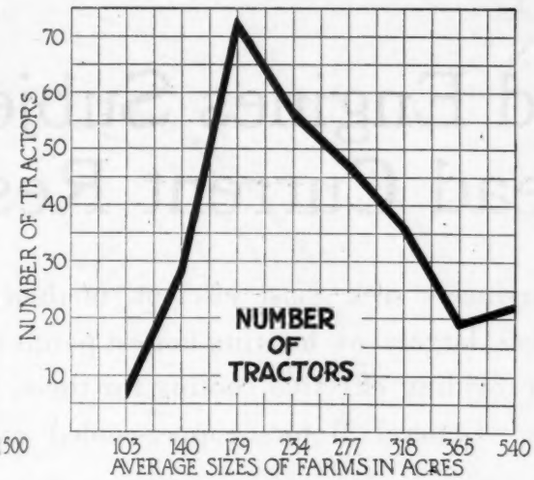


Fig. 7—Distribution of tractors on corn belt farms by sizes of farms

generator for soil preparation and belt work. This brings up a number of interesting questions including: How far can the present type of tractor go in meeting the farm power requirements? How much can farm practices be changed in order to make them better adapted to the present types of tractors? Can a combination of the motor cultivator and tractor as now built meet the farm power requirements? If so can the small farmer afford to purchase both machines? What field is there for the general purpose type of tractor?

This brief presentation of some of the results which can be secured from a formal analysis of the field for the tractor in American agriculture is simply an appetizer which, by no means, exhausts the possibilities. Numerous other reports are available, which have not even been referred to. Work of this character has never received the public support to which it is entitled. Our agricultural colleges and the U. S. Department of Agriculture could do more extensive work if the necessary funds were available, and making funds available for such work depends in no small measure upon popular support. Just think what it would mean if the $365,000 appropriated by the present Congress for free seeds had been appropriated for farm power investigations.

There is a growing belief among executives of the tractor industry that the possibilities for the use of the tractor in industry are much larger than have yet been realized. For example, it is reported that the Ford Motor Co. has instituted an intensive tractor drive in the industrial field. Unfortunately we have not been able to find even a trace of an extensive investigation of the possibilities for the use of the tractor in this important field.

In times past, which can easily be remembered, the export trade has taken an important part of American tractor production. Government export figures are as follows:

Year	Number of Tractors Exported	Per cent Total Production
1917	14,854	23.6
1918	36,351	26.7
1919	19,693	11.9
1920	29,143	14.4

This is an excellent showing when the unsettled condition of the exchange situation is taken into consideration. The officials in the Department of Commerce consider the export market for American tractors and other farm machinery of sufficient importance to appoint a man whose special duty is to collect and disseminate all possible information regarding export demands and markets. Reports are now coming through from this source. In addition to analyzing the foreign market the Department of Commerce has revised the export list so that complete information will be available in the future regarding tractor exports. There is no reason why this government department should not be of increasing value to the tractor manufacturer and render material assistance in opening up the foreign markets. Its work furnishes an excellent foundation for the individual manufacturer to build his investigations of the foreign market on.

Magnetic Tests of Chain

THE cross links of non-skid chains are case-hardened, so as to be able to withstand the wear of hard roads. If the case is of insufficient depth the link wears out quickly, whereas if it is too deep or if the chain has been quenched at too high a temperature the latter is too brittle and is liable to break. A test which gives a check on the surface hardness and brittleness is therefore required, but unfortunately the usual hardness tests, such as the scleroscope and the Brinell, are difficult to apply. At the plant of the American Chain Co. a magnetic method of testing the properties of case-hardened tire chain has been applied successfully, and an account of the method was given in a paper read by A. V. de Forest, research engineer of the company, before the New York Section of the American Society for Heat Treating.

Resistance to wear and resistance to shock are in general inversely proportional to each other, and the point of maximum usefulness is highly indeterminate. The final test, the mileage run on the road, is so subject to accidental variations that the average of a large number of records must be considered. If the depth of case is considered the only variable, if the chain is made from the same wire and carburized in the same compound at the same temperature for different lengths of time and is quenched from the same temperature, magnetic readings are obtained which are proportional to the depth of case. If a set of these chains, ranging from thin case to thick, are taken off after the first to break has worn through, it is found that the wear is very closely proportional to the magnetic reading.

When the chains are run until all are broken it is found that those showing the lowest and the highest magnetic readings give about the same mileage, while the highest mileage is obtained from chains giving an intermediate magnetic reading. The softer the road, the lighter the car and the lower the speed at which it is driven, the closer the maximum mileage chain will be to the deepest case or maximum magnetic reading chain. However, this hard chain is less reliable, and under severe conditions it may break after a few miles of running. The magnetic test, therefore, is used to determine when the chain has the most desirable hardness, as determined by experience.

Air-Cooled Engines Subject of Widespread Current Research

Automotive engineers seek most efficient method of direct cooling. Problem consists largely of locating hottest points on combustion chamber wall and providing effective cooling for them. Franklin has made careful studies. General Motors copper-cooled car nears production.

By J. Edward Schipper

WITHIN the last two years there has arisen a great deal of interest in air-cooled engines. This interest has not been confined to engineering circles alone, but has spread to all branches of the industry and also in some degree to the general public. With the exception of the motor boat and possibly also the tractor, there is not a branch of the automotive industry which has not felt in some degree the influence of air-cooling research.

The situation with respect to air-cooled engines to-day is rather indefinite. It is certain that we are on the eve of a period of air-cooled automobile manufacture to a degree which is far in excess of what would have been believed possible 5 years ago. We have among the foremost engineers of the country all shades of opinion regarding the subject, from one extreme where the belief exists that the air-cooled engine will eventually practically displace the water-cooled for automobile use, all the way down to the prediction of others that an attempt to use air-cooling for commercially manufactured automobiles will result in dismal failures. As in all such developments and as generally happens with such a wide range of opinion, the truth probably lies somewhere between these two extremes.

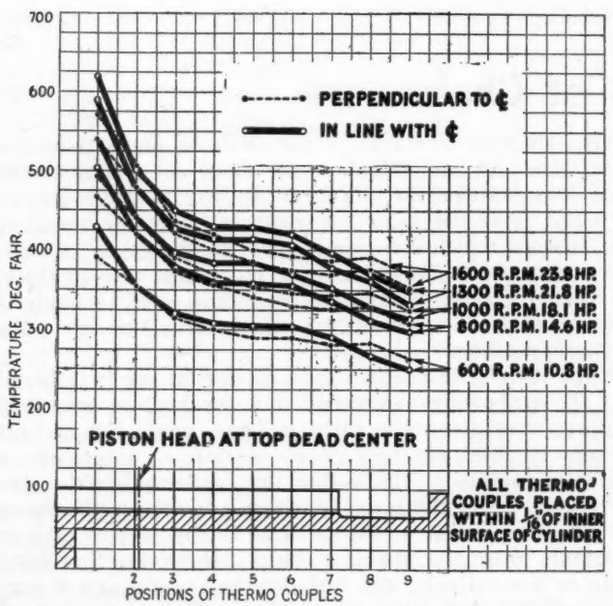


Fig. 1—Curves plotted as the result of temperature measurements on the Franklin engine, as described in text. These temperatures are taken down the side of the cylinder in nine positions

As regards small units, we have been successfully using air-cooled engines for stationary lighting plants and motorcycles. In large units, we have had successful airplanes which have operated with air-cooled engines with cylinder bores well above what would be required for automobile use. However, in aircraft work the tremendous air velocity is available for forced cooling, which somewhat modifies the conclusions which can be drawn from these successes insofar as applying them to automobile practice is concerned. We have one automobile engine which has been successfully air-cooled from the time of its inception and two or three other makes which have also been successfully air-cooled in this country, and some smaller air-cooled cars which have given good service abroad.

From an engineering standpoint, the prospect of the next three years in air-cooled development is entrancing. Regardless of the results accomplished and whether or not air-cooling comes into its own during the next few years, it is certain that it will leave its imprint on all engine designs, whether cooling is by air or water. As one engineer put it recently in a discussion of this subject at a meeting of the Society of Automotive Engineers, progress in air-cooling will probably result in better water-cooled engines.

Whether or not air-cooling is to be successful depends on whether it is possible to secure the same economy, quietness of operation and continuity of performance as with water-cooling. The power output per unit of displacement depends on compression ratio to a large degree. The allowable compression ratio depends very largely on the efficiency of cooling and the ability to eliminate hot spots in the combustion chamber. Consequently, with air-cooling, it is necessary that the hot points in the cylinder be located and dealt with in such a way that the temperatures of these points do not rise to a degree sufficient to reduce the allowable compression and, consequently, to correspondingly reduce the output.

In considering the power output of an air-cooled engine, it is necessary to consider the net output secured by deducting the power consumption of the cooling fan, and one of the objections generally offered against the air-cooled engine is the fact that this output runs up very fast with increase in speed.

Very extensive research work with a view of the further development of the air-cooling system has been done by the H. H. Franklin Mfg. Co. The Franklin engine is cooled by a positive current of air through a jacket sur-

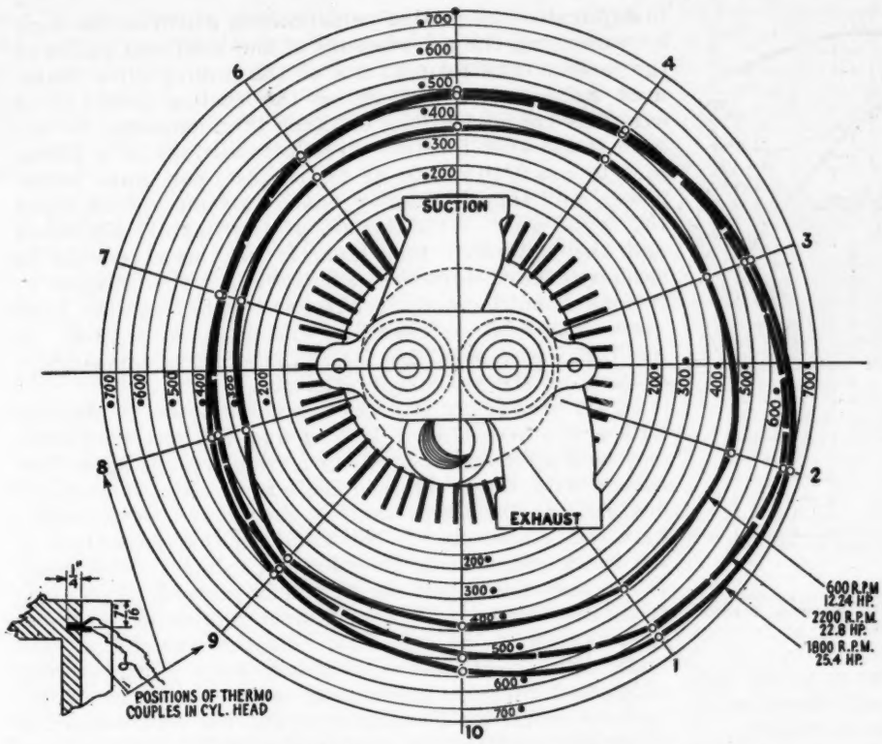


Fig. 2—Temperatures taken on Franklin cylinder head at equal distances of ¼ in. from the outside of the wall and 7/16 in. below the top of the cylinder head

rounding the cylinders. The cooling air comes in intimate contact with sheet metal fins cast into the cylinder wall. The valves and the spark plug boss are in the head, which has no cooling fins. Naturally, the cylinder head is the part which attains the highest temperature in operation, because it has only a comparatively small cooling area and is in contact with the burning gases throughout the power stroke.

In the research work carried out by the Franklin company, temperatures were measured at several points on the cylinder head, all around the circumference of the head and along the length of the cylinder casting both on the sides of the engine and between the cylinders, so that curves of temperature variation could be plotted for practically the whole cylinder. The temperature of any point in the cylinder wall varies with the conditions of operation of the engine; that is, with the crankshaft speed, the spark timing, the horsepower output, the richness of the charge, etc., of course, the highest temperatures occur under the condition of full throttle operation, and this is the condition under which the research work was carried out.

Temperature measurements were made by means of the Leeds & Northrup potentiometer system. This has been used extensively in the past for the measurement of temperatures in the heat treatment of steel. At first some difficulty was experienced in getting results to agree, but these were overcome and results can now be duplicated with only an insignificant error. In order to be able to accurately define the conditions of engine operation, it was necessary to provide means for measuring the air and fuel entering the engine.

For measuring the air use is made of a Venturi tube type of air meter. All of the air entering the engine is passed through a venturi tube of suitable size, the static and dynamic pressure of the air at the throat of the tube are measured by means of water columns, and from these pressures the speed of the air through the throat is calculated. In conjunction with the area of the throat, the temperature and the barometer reading, this gives the weight of air passing per unit time. This air meter is clearly seen in one of the illustrations herewith. An air meter of this type is quite simple to construct, and as it has no moving parts, it cannot get out of order.

Some of the curves plotted from the results of the temperature measurements are reproduced herewith, Fig. 1. One of the charts shows the variation of temperatures down the side of the cylinder in nine positions 1 in. apart, the first position being 1 in. below the top face of the cylinder head. There are two sets of curves, the full-lined curves giving the temperatures in line with the axis of the engine, or, in other words, between adjacent cylinders, whereas the dotted line curves give the temperatures at the side of the cylinder or perpendicular to the engine axis. In this case the temperatures were measured on cylinder No. 1 on the exhaust side and in the rear. All joints of thermo-couples were placed within 1/16 in. of the inner surface of the cylinder wall. It will be noted that all curves of the same kind follow some definite law. The highest temperature reached by any part of the cylinder wall with which the piston comes in contact is substantially 500 deg. Fahr. The temperature drops very rapidly from the top of the cylinder to a point about 1 in. below the beginning of the stroke, but there is comparatively little drop from this point down to the end of the stroke. That the temperature of the wall in the axis of the engine is slightly higher than at right angles thereto may be due either to

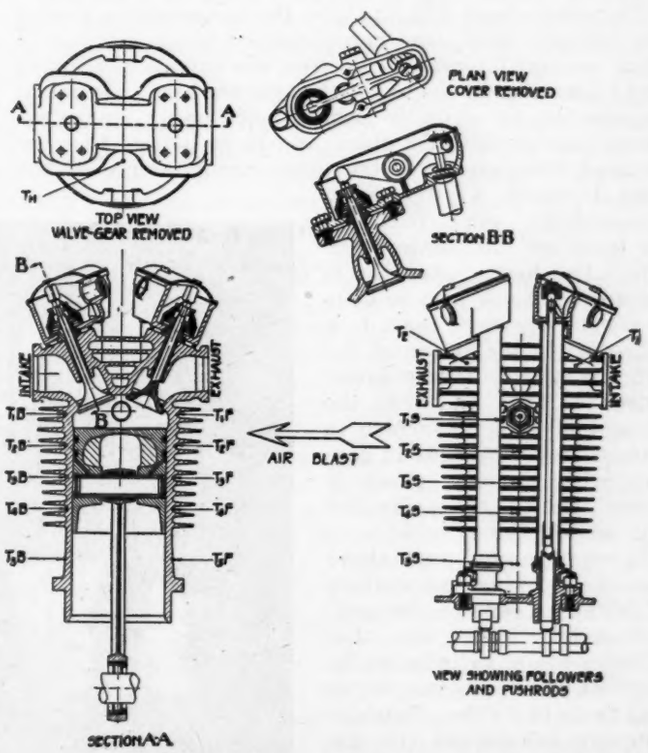


Fig. 3—Plan view and sectional elevation of cylinder used in the B. S. A. passenger car described in S. D. Heron's paper before the Society of Automotive Engineers

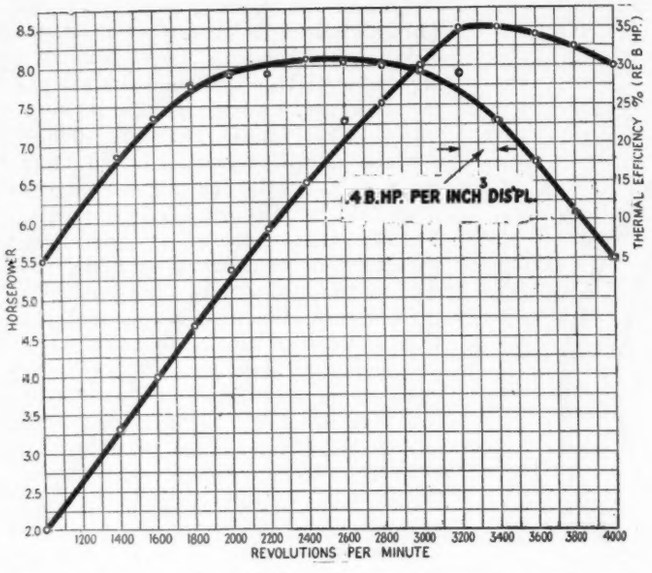


Fig. 4—Power curves showing the brake horsepower developed at various engine speeds up to 4,000 r.p.m. on the Barr & Stroud single sleeve valve, air-cooled engine

radiation effects from the adjacent cylinder or to the fact that the jacket space in the fore and aft direction is somewhat shallower than in the transverse direction.

It is quite obvious from this chart that the average wall temperature of an air-cooled engine is materially higher than that of a water-cooled engine, as the latter cannot be much above 212 deg. at 1/16 in. from the inner surface of the cylinder wall. The Franklin company made experiments with an engine in which the cooling wall temperature was gradually decreased to about 212 deg. by increasing the intensity of the cooling action, and found that the efficiency of the engine from the standpoint of fuel consumption decreased with the wall temperature from 400 deg. down.

The other chart, Fig. 2, shows the temperatures around the cylinder head, ten thermo-couples being inserted at equal angular intervals ¼ in. from the outside of the wall and 7/16 in. below the top of the cylinder head. As might be expected, the cylinder head is much hotter on the exhaust than on the inlet side. It will be noticed that the extreme temperature of the outer circumference of the head is about 65 deg. Fahr. Undoubtedly, some parts of the head get still hotter than this. The head, naturally, is the most difficult part to cool, owing to the fact that it is subjected to the action of the hot gases for the greatest length of time and that the amount of cooling surface in proportion to the area in contact with the hot gases is much smaller than for the side wall of the cylinder.

It was pointed out above that the working temperature of the air-cooled cylinder wall is materially higher than that of water-cooled cylinder walls, and this point is borne out by the fact that the Franklin company recommend the use of cylinder oil with a specially high fire test.

In all tests, it is endeavored to duplicate road cooling performance, which can be done by measuring the air pressure at the inlet and outlet of the jacket. The temperature of the cooling air is measured as it enters and leaves the cooling jacket with carefully calibrated long distance thermometers. It has been found that for full throttle conditions it is necessary to use 9/10 cu. ft. of air per sec. per brake horsepower, and the air then is raised in temperature about 100 deg. Fahr. With the aid of the venturi air meter and the calibrated fuel tank, it has been possible to measure the volumetric efficiency of the engine at various conditions of carbureter setting, suction yoke (inlet manifold) arrangement and camshaft setting. It has been possible to also study the effect of temperature changes on the volumetric efficiency.

It has been found that the maximum power is obtained with a mixture ratio of 12 to 1 and the maximum economy with a ratio of about 17 to 1, which results agree very closely with those obtained by others with water-cooled engines. In the temperature explorations thermo-couples have been placed even in the tip of the center electrode of the spark plug and in the inlet and exhaust valve heads. It has been found that the maximum economy is obtained from the engine with a maximum combustion chamber temperature of 550 deg. Fahr. and that the engine runs under these conditions without any signs of stress from either heat effects or mechanical loads. As a result of this research work, the Franklin company has been enabled to materially increase the compression ratio of its engines. In the words of Mr. Grimes, research engineer of the Franklin company: "Neither the compression ratio, volumetric efficiency nor cylinder head temperature can alone convey any definite meaning even to the engineer who must realize that the indicated horsepower is a function of the weight of the compressed volume and its pressure at the time of ignition."

The pressure alone is limited by the cylinder head temperature, whereas the compressed volume is limited by the ability of the cylinder to disperse the heat absorbed by its walls and thus remain at all times below the preignition point. The compromise of the three factors was decided upon a gasoline economy basis.

The preignition limit of cylinder head temperature must never be exceeded. The volumetric efficiency is then developed to the greatest value that will produce a uniform compression throughout the speed range of the engine.

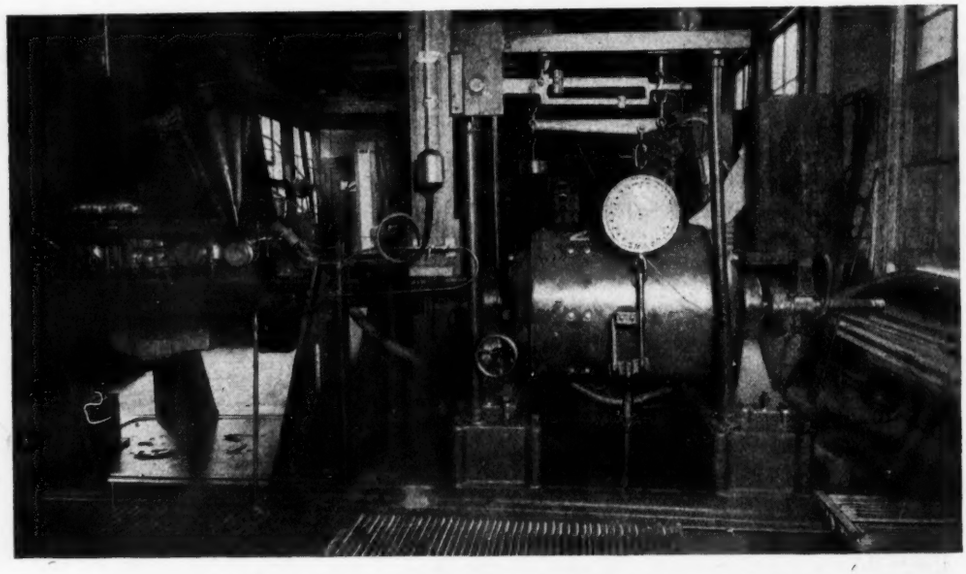


Fig. 5—Dynamometer stand used for tests on Franklin air-cooled engines

Should this uniform compression value cause preignition, the combustion space is then increased by the use of shims until preignition is eliminated. This procedure has invariably resulted in excellent economy, no small part of which is due to the use of a hot cylinder head which is of great assistance in burning the low grade fuels of to-day.

Little or nothing has as yet been disclosed by the General Motors Co. regarding research work on the copper-cooled car. In all probability, this car will find its way on the market during the fall of 1922. After that time, some very interesting facts will probably be brought to light on the development work behind this new air-cooled product. It is generally known, however, through the trade that the two big developments behind this project have been the discovery of means of amalgamating copper and iron in such a way that copper ribbing can be used for the cooling fins and the machine which has been developed for crimping the copper so that the ribs taper in depth in such a way that the cylinders can be brought very closely together without overlapping the cooling fins to any extent, if at all. The heat conductivity of rolled copper is approximately 2.35 times that of cast iron. Based on a figure of 1000 for silver, rolled copper has a conductivity of 845 as against 359 for cast iron (Kent). With the copper fins, therefore, a greater amount of heat will be conducted from the combustion chamber walls in a given amount of time for a given area of cooling surface. To put this in another way, if the cylinder size is fixed for cast iron by the ability to remove the requisite number of heat units per unit of time with cast iron, this cylinder size will not be as large as that which can be taken care of by the same proportionate heat removal with the copper fins.

S. D. Heron, in his paper on some aspects of air-cooled cylinder design and developments, presented before the Dayton Section of the Society of Automotive Engineers recently, stated that investigation has shown that for every brake horsepower developed, an average of approximately 0.6 hp. or 25 B.t.u. per min. has to be dissipated directly to the cooling air or the external surface of the cylinder. In addition, he states, 0.4 to 0.5 hp. has to be dissipated by the oil, by conduction to and radiation from the crankcase and similar means. The amount of heat absorbed by the oil will depend largely upon the amount reaching the cylinder and the piston walls and the facilities for cooling the oil. Power output, fuel consumption and

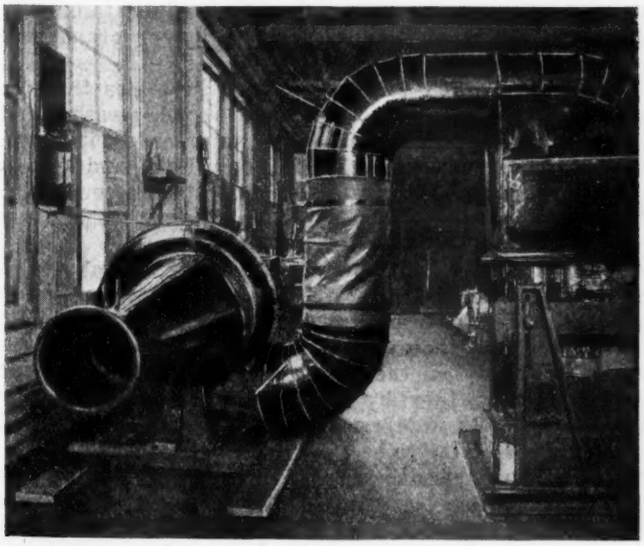


Fig. 6—Venturi measuring device used in tests on Franklin engines

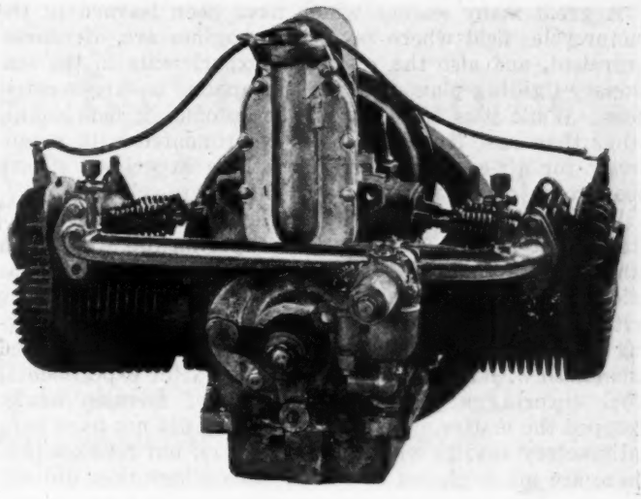


Fig. 7—Two-cylinder, horizontal opposed air-cooled engine used by Buda Co. for propelling its rail car

cylinder wall temperatures such as are quoted herein, are dependent upon liberal splash lubrication and the resultant oil cooling. This leads him to the following three conclusions, which are required for a design of a cylinder with high output (for aircraft work):

1—It must develop a volumetric efficiency of 80 to 85 per cent.

2—It must produce a brake mean effective pressure of at least 130 lb. per sq. in. at the normal speed on a maximum fuel consumption of .56 lb. per b. hp. hr.

3—It must dissipate 25 B.t.u. per min. per b. hp. from the external cooling surfaces of the cylinder, this heat to be dissipated so that the maximum temperature of any portion of the exterior of the cylinder wall does not exceed 550 deg. Fahr., and it is preferable that it be lower. In addition, the mean temperature of the exterior of the cylinder walls should not exceed 350 deg. Fahr. To produce a layout that fulfills the standard requirements, it is necessary that heat flow be the primary point in mind during design.

Mr. Heron, in his paper, is, of course, speaking largely of aircraft practice. Nevertheless, much of what he gives in his paper is applicable to automobile as well as airplane practice. He cites, as an example of what may be accomplished in the way of automobile engine cooling with small air supply, the British B. S. A. light car, the cylinder of which is illustrated in Fig. 3. This car has a 90-deg., two-cylinder V-engine of 66 cu. in. capacity and is cooled entirely by natural draft, no fan being employed. One of the early engines was fitted to a car weighing 1500 lb., including passengers and regular equipment, and road tests of the cylinder temperature under these conditions are interesting. Climbing a hill rising 1200 ft. in 2½ miles, the temperature at T-H, Fig 3, the hottest part of the hottest cylinder, was 310 deg. Fahr. above the air temperature at the start of the ascent and 495 deg. Fahr. at the finish. This ascent was taken on the run with the engine at normal temperature and was made in a following wind in 11 min. There is little question that the heat storage capacity of the cylinders is of considerable importance in preventing overheating under such conditions, as prevailed in this test.

The heat storage capacity of a water-cooled car engine having a large quantity of water in the jackets and the radiator, in this sense a heat accumulator, is known to be of advantage in preventing boiling in mountainous countries. This is a parallel tending to show the similar advantage of thick, heavy cylinders for air-cooled cars.

A great many lessons which have been learned in the motorcycle field where small bore engines are, of course, prevalent, and also the results of experiments in the stationary lighting plant field may be applied to larger cylinders. While it is true that in the automobile field metals other than cast iron have been experimented with extensively for air-cooling only lately, these experiments have been going on for some time in the motorcycle field.

William S. Harley, of the Harley-Davidson Motor Co. states that his concern has done experimental work with other metals than cast iron and in this connection has tried aluminum, brass and steel. In his experimental work with aluminum cylinders, he has made new patterns having cylinders with cast-in bronze valve seats. He has tried them both with and without sleeves and after experimental work covering a period of a couple of months, finally dropped the matter. He states that they did not have very satisfactory results with these cylinders, but realizes that there are many phases to the problem which they did not go into. The results he got from these tests were largely inconclusive, but from his experience with other metals he is inclined to think that cast iron is the best material for air-cooled cylinders.

A NUMBER of years ago motorcycle engines were built with copper cooling fins on cast iron cylinders. The Orient motor built at Waltham, Mass., was of this type. Harley-Davidson have built an experimental motor with 3-7/16 in. bore by 4 in. stroke. This engine, Mr. Harley states, is working very successfully and he believes that on automobiles, larger bores than this could be used as they have greater possibilites of more regular and more efficient cooling.

Barr & Stroud, Ltd., of Glasgow, are manufacturing a single cylinder, sleeve valve motorcycle with air-cooling which shows a great deal of promise and some extraordinary performance features. Fig. 4 is a horsepower curve of this engine. It is rated at 3 hp. and has a displacement of 350 cc. with 70 mm. bore and 90.5 mm. stroke. The compression ratio in this engine is four to one. This engine operates upon the same cycle as the well-known Argyle single sleeve, which is familiar to our readers.

Another interesting sidelight upon the compression ratio problem is furnished by N. J. Harkless, Engineer Railroad Dept., of the Buda Co. The Buda Co. has been building a two-cylinder, opposed air-cooled engine for a number of years. These engines are used in connection with railway motor cars for section gangs. In this engine, the compression ratio is 3½ to 1, which has been found most practical for this purpose. There is no cooling means other than a fan flywheel, which is not very effective in assisting in cooling. These engines are built in three sizes, a 4¾ by 4½ bore and stroke, 4 by 4 and 3½ by 3½ in. Although a heavy grade will overheat these engines when pulling heavy loads, in general the engines do not overheat. With these cars, runs of 200 and 250 miles per day with average speeds of 30 to 35 miles per hr. are common. In these runs, the only stops are at lunch time and to set off for trains. On this type of run, no overheating is experienced, as the load is very light, with 3 to 4 men, and the speed high enough for sufficient air draft for cooling.

A general survey of the present situation seems to indicate that the cast iron cylinder remains supreme in spite of the fact that experimenters have dabbled very heavily in aluminum, the copper alloys, etc. The possibilities of using metals of higher conductivity for cooling fins on cast iron cylinders have not been exhausted. This has been and is being done as, for instance, in the General Motors copper-cooled car.

Henry M. Crane, however, states that recent research on air-cooling seems to indicate that other design factors may be of such importance that the use of other metals than iron for ribs may not be necessary. Going further on this subject, Mr. Crane states that he doubts the economical value of air-cooling in automotive engines for anything but very moderate horsepower. The cost of operation and upkeep, he says, is high comparing these items to well-designed, water-cooled engines.

To look again at the negative side, the composite case against the air cooled engine for automobile work seems to be something along the following lines:

With water we have a fixed operating temperature. The temperature at which the engine operates can be predetermined. With air, many engineers claim it is not fixed, and may vary to a considerable range.

A practical objection which is often advanced against the air-cooled car is that it is difficult to make it quiet. It is claimed that the ribs on an air-cooled engine are conductors of both heat and sound. Because of the higher temperature of the air-cooled engine, greater clearances are necessary. With water-cooling, it is claimed that the clearances can be fixed more definitely because we can fix the operating temperatures of the water-cooled engine. This applies to valve mechanism as well as other parts. The greater difference in expansion due to the increased temperature of the air-cooled engine accounts for this.

In criticizing the air-cooled car, one prominent water-cooling advocate recently stated that improving road conditions throughout the country are forcing better performance and ability to run continuously at higher speeds, which is a difficult condition for the air-cooled car to meet. He states that it is only possible to remove a limited number of B.t.u. per min. from the combustion chamber walls. The distance through metal through which heat must be transferred on a water-cooled car is very slight. There are no cooling fins necessary and the thickness of the copper in the radiator is so slight that heat transfer is very rapid. On the other hand, he states that the cross-sectional area available to remove heat through the wall is greater in the water-cooled engine than in the air-cooled. In the water-cooled engine, there is 100 per cent cross-section, whereas with the cooling fins, part of this is lost.

REGARDING the weight situation, this same engineer states that it is doubtful whether the air-cooled car, in spite of its absence of radiator, saves any weight as compared with the water-cooled because of the weight of the air fan apparatus and also because of the necessity for leaving space for the cooling fans. He claims that this makes necessary a longer crankshaft and crankcase.

Regarding the efficiency of cooling, he states that the air-cooled engine is apt to be too cold in cold weather and too warm in warm weather. With water-cooled, it is possible to design the engine for 212 deg. Fahr. and keep it at that temperature regardless of atmospheric conditions. A further objection advanced is that the oil temperature is higher in the air-cooled engine.

With all of these objections, nevertheless, the air-cooled car is rapidly advancing to the point where we are going to see it marketed commercially through our automobile salesrooms, and there will shortly be numbers of them on the road. When the first of the production cars are out on the road, they are going to be scanned eagerly by engineers of both water-cooled and air-cooled leaning, and opportunity is going to be afforded for some very interesting and instructive debates on the subject. It is certain that the last three years have seen some material advances in air-cooled engines for all fields of automotive use and we are standing on the threshold of some of the industries' most interesting developments in this field.

Automotive Engineering Development Rests Largely on Fuel Research

Dependence upon foreign fuel supplies increases with decline of domestic reserves. Gasoline substitutes, especially alcohol, are already extensively used in other countries, but are not available in significant quantities in this country. Cracking processes being developed. Fuel volatility affects utility. Work of Ricardo and of Kettering and his associates is important.

By Herbert Chase

RESEARCH work pertaining to fuel suitable for automotive uses has brought into prominence many facts of far reaching import to the automotive industry. Among the important facts established in this connection the following need emphasis:

1. Conservation of motor fuel resources is necessary to prevent rapid depletion of the domestic reserve. This country is already dependent to a large degree upon imports of petroleum.

2. Gasoline substitutes are not available in significant quantities in this country, though the resource exists when conditions warrant its development on a large scale.

3. Alcohol is an excellent motor fuel. It can be produced in large quantities in competition with gasoline in many foreign markets, especially as a by-product of the sugar refining industry. Half the automotive vehicles in Cuba are reported to be using alcohol fuel at the present time. The Philippines can be easily made independent of motor fuel imports by developing potential alcohol reserves.

4. The use of fuel alcohol and blends containing it is of importance to American automotive manufacturers, especially exporters, because such fuels are now available in many parts of the world, even to some extent in this country.

5. Alcohol possesses many advantages as a fuel. Its disadvantages can be overcome or neutralized by its proper preparation and by adapting equipment to its use.

6. Cracking processes in which the yield of gasoline is very high are in process of development. Some of them give promise of materially increasing the available supply of gasoline from the crude, but none save the Burton process have yet been proven successful on a large commercial scale.

7. It has been proved that the tendency of a fuel to detonate is of great importance in respect to its suitability for automotive use. Thermal efficiency is largely dependent upon compression pressure, and increases with the pressure. Of the commoner fuels the paraffines detonate at the lowest pressures, while the alcohols withstand the highest pressures without detonation. The naphthenes and aromatic are between the two in this respect. Aromatics are next to alcohol in effectiveness.

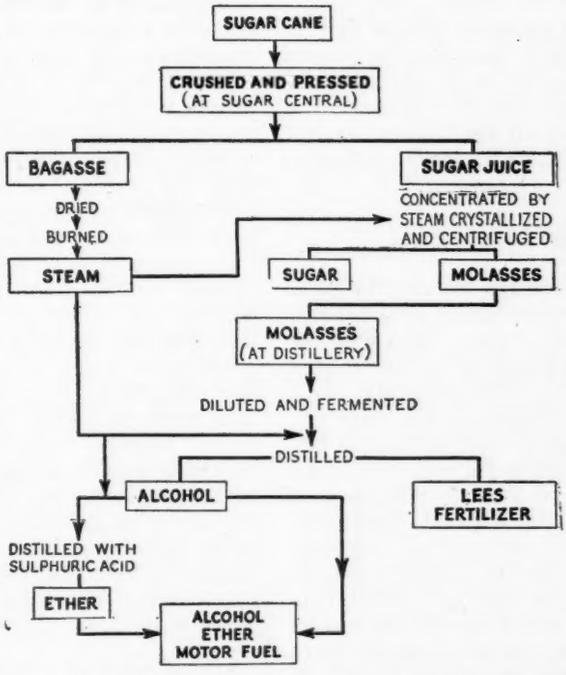


Fig. 1—Diagram of the process of manufacture of alcohol-ether motor fuel from by-products of the sugar industry, prepared by Dr. H. I. Cole

8. The volatility of a fuel is of great importance as affecting its utility. The readiness of a fuel to vaporize is being investigated, and some important findings in this respect are given in the following pages.

9. All fuels, when combined with air in proper proportions for complete combustion, give approximately the same power per unit of volume when used at the same compression pressure, providing detonation does not occur.

10. The fuel economy of automotive vehicles is dependent upon mixture proportions, uniformity of distribution, engine temperature, frictional losses and many other factors, several of which are discussed in the following pages.

Among the outstanding research activities within recent years there are none of more importance to the automotive industry than those relating to a study of motor fuel and its performance under conditions simulating those encountered in use in internal combustion engines. There are numerous experimenters in this field, but it is probably true that none have, so far as the public is informed, done more than Harry R. Ricardo and his associates. A record of this work has been published in these columns and elsewhere and has been the subject of much favorable comment, though some are disposed to criticize some of the methods followed and results obtained. The Bureau of Standards, General Motors Research Corporation and the International Harvester Co. among others, have done much commendable work, but few industrial organizations have been so

public spirited as the Asiatic Petroleum Co., for whom much of Ricardo's work was done, in permitting publication of comprehensive reports on the work done. A number of the oil companies in this country are known to be conducting research work on fuels and lubricants, but their work is, for the most part, held a strict trade secret, so that few but themselves benefit from whatever results are obtained.

Ricardo appears to have been one of the first European engineers to recognize the importance of the tendency of fuels to detonate in relation to the effect of this characteristic upon their suitability for use in internal combustion engines. C. F. Kettering and his associates had been giving this factor much study and had made reports in which various classes of fuels had been arranged in order in respect to their detonating tendency, but Ricardo's reports appear to have been the first published in which an effort was made to assign definite detonating values in terms of a fuel of known value. Ricardo demonstrated experimentally that thermal efficiency and the power available from unit volumes of liquid fuels combined with air in chemically correct proportions for complete combustion is, within 2 per cent, the same for all or nearly all fuels, when these fuels are used in a given engine with given expansion ratio, providing the compression is not high enough to cause detonation. Ricardo investigated numerous other fuel characteristics, as will be noted under various heads below. His published reports are among the most comprehensive which have come to our notice, and are worthy of careful study.

It is proposed in the following pages to review briefly under about a dozen different heads fuel research work which is now known to be in progress or which has been in progress or completed within about 18 months. We shall then consider the combustion of fuel under several headings and follow this by an outline of engine research and development in relation to fuel economy.

The Available Supply of Liquid Fuel

In spite of certain temporary quieting factors the need for conservation of the liquid fuel resources of the world becomes more and more apparent to those who give the subject study. There is no such thing as an "accurate" estimate of petroleum reserves, even in this country with its relatively excellent geological surveys—the very nature of petroleum occurrence makes exact estimates impossible—but the basis upon which resources in oil can be estimated are becoming more and more definite as a result of experience. Following the methods developed by the important oil companies of the country and with the full co-operation of these companies and independent geologists the U. S. Geological Survey completed this year a new survey which places our domestic reserve at nine billion barrels. This increases the previous estimate by nearly 70 per cent, but the total remaining supply is small in relation to the continually increasing annual demand which has reached a total of about a half billion barrels for this country alone. Already some 20 per cent of our domestic petroleum requirements are imported from failing sources in Mexico and there is reason to question whether this country will ever again be able to supply its need from domestic fields.

Investigations as to foreign supplies which may in time become available have progressed far enough to indicate promising possibilities, but reports on the quantity of petroleum available are highly speculative and it is certain that many years will elapse before reserves in this hemisphere, but outside this country, are developed sufficiently to have any marked effect on the domestic market. When and if available these supplies are certain to be far more expensive than those secured at present from domestic sources.

There is consequently need for much research to determine how great reserves of shale oil can be made available in place of petroleum. Work along this line is progressing slowly and on a totally inadequate scale. It is evident that shale oil cannot be recovered profitably in competition with petroleum until the price of the latter has reached a higher level than it has ever attained in this country, and then a mining industry comparable in extent to the coal mining industry of this country will be required to supply liquid fuel in adequate amount. Research work on shale oils has shown clearly that a usable motor fuel can be made from them, but much remains to be done in research and development work before such fuel is available in significant quantities.

Substitute Fuels

Aside from shale oil distillates, the possibilities of other substitutes for gasoline are not promising in this country, except in a decidedly limited way or as an auxiliary to supplement and improve gasoline. The advantages of benzol, toluol and other coal tar products as knock deterrents are becoming more generally appreciated, thanks to the work of Kettering and his associates, Ricardo and others, but the quantity of such products available, even if all the bituminous coal mined in this country were treated for their recovery, is extremely small as compared to the total demand for motor fuel. It is a physical possibility to produce alcohol in this country in quantities sufficient to at least help materially the supply of motor fuel, but the investment necessary in the way of distillation apparatus would be enormous and the production and accumulation of sufficient raw material to meet such a demand presents such a problem as to make its practical accomplishment in this country almost unthinkable on any scale comparable in respect to output with that of the present petroleum industry.

In countries such as Cuba, where alcohol can be made cheaply and in quantities sufficient to meet the national demand for motor fuel from by-products of the sugar industry and where gasoline is relatively expensive, the problem of using alcohol fuel is of immediate interest and importance even to American manufacturers, for it is to them that such countries look for automotive equipment. Blended fuels in which alcohol is one ingredient may also become an important factor in our domestic market, consequently an investigation of their performance is worthy of close study. Much experimental work is now being done along this line, as we shall shortly see, but before we examine the data concerning the use of alcohol a few items regarding substitute fuels in which alcohol is one component will be given.

Blended Fuels

In Germany, as in France and some other European countries, considerable quantities of alcohol are available for motor fuel, and the high price of gasoline as well as a desire to be independent of fuel imports has resulted in the governments encouraging or insisting upon the use of domestic products. Thus Germany has adopted a new standard fuel which consists of 50 parts benzol, 25 parts alcohol and 25 parts tetralene, $C_{10}H_{12}$. Tetralene is made by the hydrogenation of naphthelene, $C_{10}H_8$, a coal tar product which is a solid at ordinary temperatures. Tetralene has a low freezing point, a high boiling point and a heating value of 20,900 B.t.u. per lb. and the plant capacity for making it is said to be 30,000

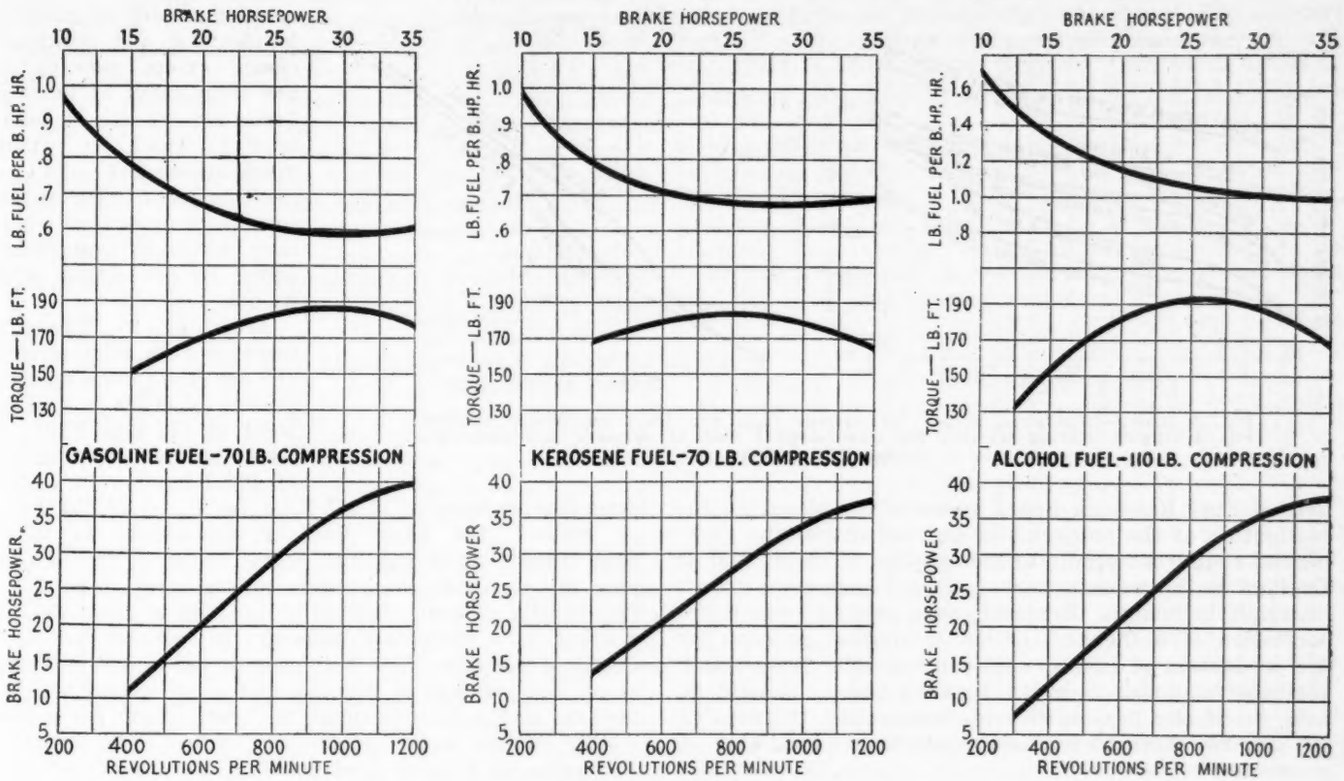


Fig. 2—Power, torque and economy curves of Twin-City tractor engine, showing performance on alcohol as compared to gasoline and kerosene

tons per year, or half the capacity for benzol production in Germany. Taking these two and adding to them 30,000 tons of alcohol makes an annual supply of 120,000 tons of motor fuel, which is said to be more than enough for Germany's domestic needs. The standard German fuel has a favorable distillation curve, a heating value of 17,200 B.t.u. per lb. and will withstand high compression pressures without trouble from detonation.

In France a so-called "national fuel," composed of alcohol and benzol in equal proportions, is being marketed under government auspices. The benzol is obtained from Germany, but alcohol is a native product which the government desires to see used in place of imported gasoline. Other experiments are being made to develop an acceptable fuel entirely from native sources.

The British use alcohol-gasoline-benzol mixtures to some extent and are much interested in alcohol fuel and its economical production both for domestic and colonial use. The Empire Motor Fuels Committee is conducting tests upon engines using alcohol, alcohol-benzol and similar mixtures to ascertain which of these can be used to best economic advantage in engines of existing design and how present designs should be modified to use these fuels to best advantage. Tests are to be made first with 95 per cent alcohol and then with various mixtures containing alcohol, benzol and ether. These are to be made on engines running at various speeds, mixture ratios, compression ratios (up to 7:1) with throttle wide and partly closed and with varying amounts of heat added to the entering charge.

The London General Omnibus Co. has made extensive tests with mixtures of alcohol and benzol as well as with these two plus a small percentage of ether. In the case of mixture of 50 per cent alcohol and 50 per cent benzol a compression pressure of 123 lb. gave best results. It was found that the higher the percentage of alcohol the higher could be the compression ratio and consequently the higher the thermal efficiency obtained. With a compression of 160 lb. per sq. in. a mixture of 70 per cent alcohol and 30 per cent benzol gave the best all around results. In service tests, presumably with engines of normal compression for gasoline, it was found that a 50-50 alcohol-benzol mixture resulted in the least number of thermal units consumed per mile and consequently the highest thermal efficiency. The relative ease of starting, accelerating ability and flexibility were notably good, while fuel knock or pinking were non-existant. Use of sufficient heat to fully vaporize the mixture was found to be important.

Mixtures containing benzol and one or more of the following: gasoline, kerosene, alcohol and ether, have been marketed at various times in this country with more or less success even in competition with lower priced gasoline. Blends containing alcohol have, however, given some trouble as a result of corrosive action, a factor which will shortly be considered in detail, and some such have been withdrawn from the market on this account. Benzol-gasoline mixtures are extensively used for aviation engines in order to permit of the use of higher compressions.

Alcohol as Motor Fuel

Alcohol has long been used as a fuel for internal combustion engines, notably in Germany, and possesses many advantages as compared to present day gasoline, though it has also certain disadvantages. In many countries outside our own, in which petroleum products are imported at relatively high prices, alcohol is not only cheaper than gasoline, but is or can be made available in sufficient quantities to supply all automotive needs. Much research work looking toward its production from various raw materials has been done already and much more remains to be done. The factors affecting cost are so numerous and vary so much in different localities that each case must be considered on its own merits. The

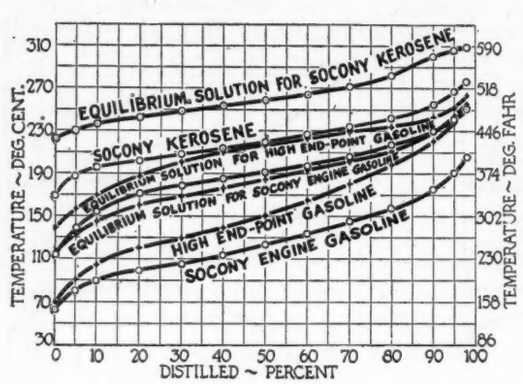

EQUILIBRIUM SOLUTION FOR SOCONY KEROSENE
SOCONY KEROSENE
EQUILIBRIUM SOLUTION FOR HIGH END-POINT GASOLINE
EQUILIBRIUM SOLUTION FOR SOCONY ENGINE GASOLINE
HIGH END-POINT GASOLINE
SOCONY ENGINE GASOLINE
TEMPERATURE ~ DEG. CENT.
TEMPERATURE ~ DEG. FAHR.
DISTILLED ~ PERCENT

Fig. 3 (Left)—Distillation curves for various fuels and their equilibrium solutions.

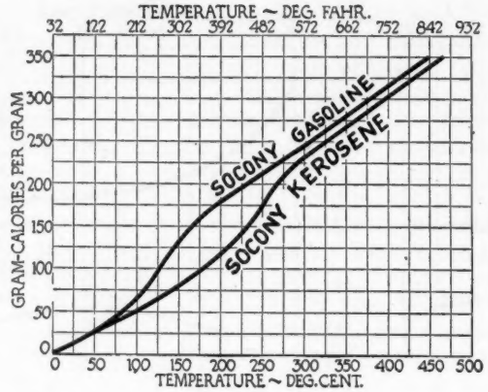


Fig. 4 (Right)—Curves showing the total sensible heat of kerosene and gasoline at various temperatures

British Fuel Research Board recently completed an investigation of the subject and concluded that the prospect of adding materially to the supplies of motor fuel in England by the manufacture of alcohol from home grown materials is remote. Research work looking toward the perfection of a chemical or bacteriological process for the production of fuel alcohol commercially from waste vegetable materials is going forward and is thought to have promising possibilities for application in parts of the empire where such waste products are available in quantities.

In Cuba and other sugar producing communities alcohol is now made and used extensively as motor fuel, the source being low grade molasses, which is a sugar refinery by-product available in large quantities. Recent advice from Cuba is to the effect that about half the cars, trucks and tractors in operation there are now using alcohol successfully, although not designed for efficient operation on this fuel. In the Philippines the Nipa palm is the source of supply of industrial alcohol. It has been estimated that 100 sq. mi. planted to Nipa palm could produce sufficient alcohol to provide a substitute for gasoline in sufficient quantities to operate all the motor cars in Australia. This plant is said to have a life of 60 to 100 years and can be tapped periodically without injury throughout its life. According to Dr. Howard I. Cole, American chemist in the Philippine Bureau of Science, who has done considerable research work in connection with investigations regarding the possible establishment of an alcohol fuel industry, the islands could readily produce alcohol in sufficient quantity to become independent of any outside source of motor fuel and even produce fuel alcohol for export. He favors the use of a fuel similar to that produced in South Africa and called Natalite, which is said to contain 55 per cent rectified alcohol, 44.9 per cent ether and 0.1 per cent ammonia, to which is added some denaturant. The ether can be manufactured along with the alcohol.

It has been estimated that alcohol, which is already used to some extent in the Hawaiian Islands as one important constituent of motor fuel, can be produced there for about 10 cents per gallon, at the same time producing a valuable fertilizer. The appended diagram, prepared by Dr. Cole, is intended to visualize the process of manufacture of sugar with by-products in the form of alcohol-ether motor fuel and fertilizer. See Fig. 1.

Without going further into the matter of the possible alcohol supply it is apparent that it can and will be produced in considerable quantities for motor fuel and is, in fact, being so produced and used in large quantities where the raw material is at hand and the price of gasoline relatively high. There is reason to doubt whether alcohol will ever be widely used as motor fuel in this country so long as gasoline is plentiful and relatively cheap, except perhaps as one constituent of blended fuels, but its use in countries to which we export much automotive equipment makes it important to consider a number of problems which present themselves in connection with its use.

According to Ricardo's research work, ethyl alcohol (98 per cent) has a specific gravity of 0.798, a boiling point of 172 deg. Fahr., a latent heat of vaporization of 406 B.t.u. per lb. and a lower heating value of 11,465 B.t.u. per lb., or 76,250 B.t.u. per gallon. The latent heat of vaporization is about three times that of gasoline, hence, although the boiling point is lower than the average boiling point of gasoline, the quantity of heat required to vaporize a given weight is about three times that necessary to vaporize the same weight of gasoline. The heat content per pound is about 60 per cent of that of gasoline, but since alcohol weighs more per gallon than gasoline, the heat content per gallon is about two-thirds that of gasoline, instead of 60 per cent.

Commercial alcohol used for fuel purposes contains, as a rule, from 5 to 10 per cent of water, and "unless especially treated, possesses a slight acidity, owing no doubt to its oxidation through aldehyde to acetic acid. A certain degree of ionization is thus produced in any fuel in which aqueous alcohol is one of the ingredients. This will lead in the case of commercial metals immersed in the fuel to local pitting and corrosion owing to the presence of impurities in the metals setting up of a large number of electrolytic couples over its surface."*

Corrosive Action of Alcohol

Trouble from this corrosive action has occurred whenever commercial alcohol or fuels in which it is one constituent have been used, unless some steps have been taken to prevent it. Research work into the nature of this corrosive action is proceeding both in England and in this country. Analysis made at the Bureau of Standards of the deposit formed in a terne plate tank in which a blended fuel containing alcohol had been used showed that it consisted of 77 per cent lead, zinc and iron oxides, 20 per cent of moisture, combustible and silicious matter and the balance aluminum, tin and copper oxides. Later strips of copper, terne plate and steel were immersed in this fuel for periods up to six days. At the end of this time the copper and steel showed unmistakable signs of corrosion and the terne plate some slight corrosion, while the same metals immersed in gasoline showed no such signs.

The London General Omnibus Co. found that in the case of benzol-alcohol mixtures the fuel tank became porous and corroded in a month's use. Laboratory tests made by them showed that copper and iron are attacked badly, brass, tin, zinc and aluminum are slightly attacked, while lead proved to be immune. Iron coated with an alloy composed of 20 per cent tin and 80 per cent lead proved to be satisfactory, while brass carbureter parts proved to be only slightly affected. Ormandy and Craven* have since found that a small amount of alkali

*Physical Properties of Motor Fuels by W. R. Ormandy and E. C. Craven, a paper read before the (British) Institution of Automobile Engineers.

tends to prevent corrosive action of alcohol-benzol on iron. Pyridine, which is a powerful base, answers this purpose, and this substance is one of those used to denature alcohol used for power purposes in Great Britain, Cuba and elsewhere. Corrosion of brass in the vicinity of soldered joints is increased, but if the solder be made of two parts tin to one of lead, this action ceases.

Alcohol is often blended with sulphuric ether, which, if not carefully refined, may contain some sulphuric acid which will, of course, attack metal parts with which it comes in contact. This acidity can be neutralized by the use of pyridine or ammoniac, according to Cuba Fabril S. A., large producers of the motor spirit used in Cuba. The official formula for this fuel calls for the addition of 10 per cent of gasoline or sulphuric ether and about 1 per cent of other diluents, including pyridine, formol and coloring matter to alcohol containing 5 per cent of water. The concern mentioned states that no trouble from corrosive action has occurred in Cuba, presumably due to the use of pyridine, and similar reports have been received from tractor makers who have sold equipment there.

The incomplete combustion of alcohol results in the formation of acetic acid, which will, of course, cause corrosion if permitted to remain in the engine cylinder or exhaust system. Such corrosion can, according to John A. Secor, be prevented by washing the engine with kerosene while still hot, after running on alcohol, or by the use of alcohol and benzol in equal proportions, instead of straight alcohol. The tendency to incomplete combustion is naturally much less when the mixture is on the lean rather than on the rich side. Proper atomization and vaporization of the fuel also tend to prevent incomplete combustion.

The Vaporization of Alcohol

Several American manufacturers who have constructed alcohol burning engines have found that it requires considerable pre-heating to secure maximum power and economy, and some of them have found that the same heating devices used on kerosene burning tractor engines perform this function satisfactorily. Although alcohol distills completely at a temperature of about 172 deg. Fahr., except for its water content, as against a mean temperature of about 430 for a typical American kerosene whose end point is about 570 deg. Fahr., alcohol requires nearly four times the quantity of heat per pound to completely vaporize it. The figures given by Ricardo are 108 and 406 B.t.u. per lb. respectively for alcohol and kerosene. This heat must, of course, be added before the fuel can be burned, but there is difference of opinion as to whether enough can be added after the fuel has entered the cylinder. It is apparently possible to get all the heat required into alcohol in the case of single cylinder engines of low or medium speed and similar results are attained in the case of the Rumley two-cylinder tractor engines in which the manifold is very short. In any case such engines have good economy on both kerosene and alcohol. In the case of four-cylinder engines, however, at least when a single carbureter is used, the distribution problem becomes more difficult and the addition of considerable heat to the charge before it reaches the cylinder has been found necessary to secure good economy, as the following records of test will show:

A. W. Scarratt, of the Minneapolis Steel and Machinery Co., found in tests of a four-cylinder tractor engine that the carbureted mixture on entering the cylinder should have a temperature of approximately 100 deg. Fahr. While recognizing that this temperature can be obtained in various ways, Scarratt found that hot air supplied to the carbureter assisted materially in vaporizing the fuel, and in engines of his design operating on alcohol it is aimed to have the entering air heated to 150 deg. Fahr., after which the mixture is again heated by hot spot or other means on its way from carbureter to engine. When the fuel mixture was maintained at the temperature mentioned it was found to enter the cylinder in a colorless, dry condition and neither pre-ignition nor detonation ever occurred.

In tests made by the J. I. Case Co. on their 10-18 four-cylinder 3⅞ x 5-in. tractor engine it was found advisable, when burning alcohol, to use all the heat available from an exhaust jacket which completely surrounded the intake manifold, although the temperature of the mixture measured as close to the inlet valves as possible ranged from 185 to 200 deg. Fahr. This was with 90 per cent alcohol, that is, with alcohol containing 10 per cent of water. In spite of the high temperature of the charge, the engine ran much cooler than when either gasoline or kerosene is used, so much so that at all loads below maximum it was found necessary to cover a part of the radiator in order to maintain the desired temper-

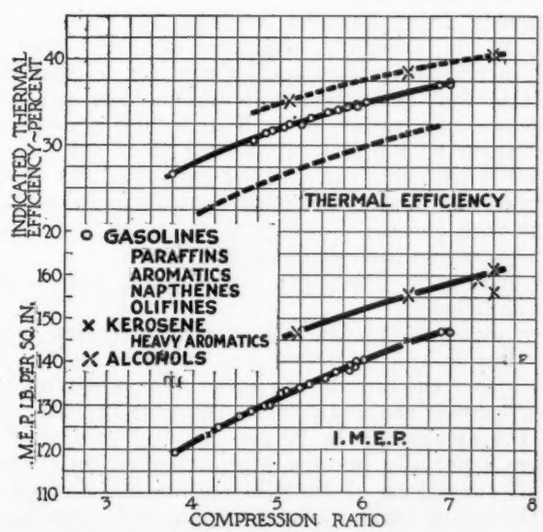


Fig. 5—Indicated M. E. P. and thermal efficiency of an engine operating on various fuels at various compression ratios, as determined by Ricardo

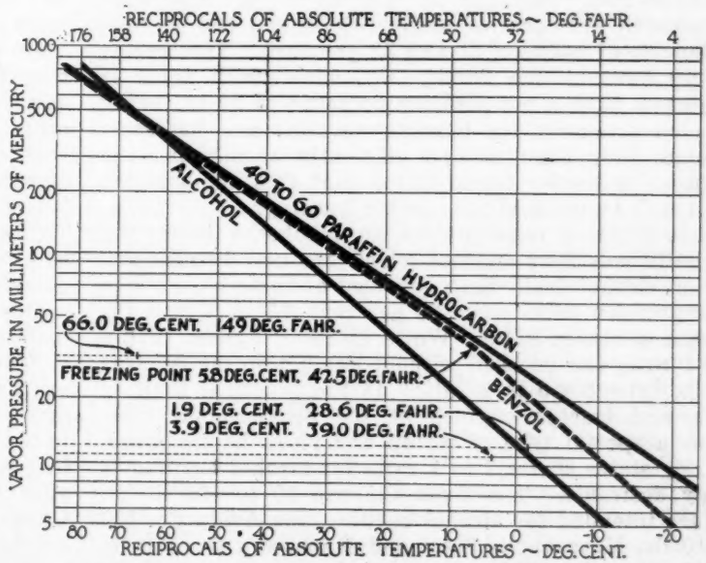

RECIPROCALS OF ABSOLUTE TEMPERATURES ~ DEG. FAHR.
VAPOR PRESSURE IN MILLIMETERS OF MERCURY
ALCOHOL
40 TO 60 PARAFFIN HYDROCARBON
BENZOL
66.0 DEG. CENT. 149 DEG. FAHR.
FREEZING POINT 5.8 DEG. CENT. 42.5 DEG. FAHR.
1.9 DEG. CENT. 28.6 DEG. FAHR.
3.9 DEG. CENT. 39.0 DEG. FAHR.
RECIPROCALS OF ABSOLUTE TEMPERATURES ~ DEG. CENT.

Fig. 6—Relation between vapor pressure and absolute temperature of alcohol, benzol and an imaginary hydrocarbon fuel

ature of the cooling water in the cylinder jacket.

Thomas Midgley, Jr., of the General Motors Research Corp., who has conducted much research work on alcohol fuel, also recommends the supply of considerable heat to the inlet manifold to facilitate vaporization.

Starting with Alcohol Fuel

Starting difficulties are sometimes encountered when alcohol alone is employed as fuel, although the large Rumely tractor engines are said to start easily on alcohol at temperatures of 70 deg. Fahr. or over. At lower temperatures starting is accomplished in the case of these engines by using gasoline. In most cases it is found possible to start readily with mixtures containing 10 per cent of gasoline or sulphuric ether, one of which constituents is used in the official motor spirit sold in Cuba. There is said to be no trouble encountered in starting there, though the warm climate is, of course, a favorable factor. One of the tractor companies supplies a longer starting crank to facilitate starting in engines designed for alcohol burning, but these engines have a much higher compression than gasoline and kerosene engines.

Compression Pressures with Alcohol

The power and fuel consumption of any engine depends to a considerable degree upon the compression pressure, and it is desirable from every standpoint to use as high a compression as can be employed without bringing about detonation which manifests itself in violent knocking, overheating, etc., and soon results, if allowed to continue, in pre-ignition.

Ricardo's research work in reference to the maximum compressions which various liquid fuels will stand without detonation shows that 98 per cent alcohol will stand well over 200 lb., equivalent to a ratio of 7.5 to 1, as compared to about 100 lb. for several samples of gasoline and 86 for one sample of kerosene. Ricardo appears to have established the fact that ethyl alcohol can be used with higher compression pressures than any other of the common liquid hydrocarbons, although acetone, benzol, toluol and xylene can all be used with compression pressures of about 180 lb., corresponding to a 7 to 1 ratio.

According to Secor, the German Deutz and other engines designed especially for use on alcohol fuel used compression pressures of about 193 lb. and had thermal efficiencies of between 31 and 32 per cent. The tractor engines built by the Rumely Co., with which Secor is connected, have a compression pressure of 90 lb., being intended primarily for burning gasoline and kerosene, although they burn alcohol efficiently considering the compression used. Secor states that this compression might well be doubled for alcohol burning.

H. L. Horning reports that the Waukesha Motor Co. has built over 2000 engines which are now being operated on alcohol fuel. Sixty per cent of these have a 4 to 1 compression ratio, some 38 per cent 4.5 to 1, and the balance a higher ratio. While Horning agrees that a 7 to 1 ratio can be used without detonation, he regards 110 lb. (about a 5 to 1 ratio) as the practical limit in truck and tractor engines of the conventional type, unless a special type of piston and rings be employed. Midgley states that a 7 to 1 ratio for alcohol burning is highly desirable. The Buda Co. use 90 to 100 lb. on engines intended for alcohol burning, the Avery Co. 100 to 110 lb., Minneapolis Steel and Machinery Co. 110 lb. and the Case Co. 125 lb.

In developing their alcohol burning engine, the Minneapolis Steel and Machinery Co. experimented with compression pressures varying from 70 to 127 lb. and finally chose 110 lb. as the compression which gave satisfactory operation and good economy. This engine is a four-cylinder, 4¼ x 6-in. type, has two inlet and two exhaust valves per cylinder and is built for 70 lb. compression when using gasoline and kerosene. The thermal efficiency, when operating on alcohol with 110 lb. compression, is equal to that obtained on gasoline at 70 lb. compression, while the maximum power developed is midway between that on gasoline and that developed on kerosene. Power, torque and fuel consumption curves for the three conditions are given in Fig. 2.

The Waterloo Gasoline Engine Co. build a line of small portable engines in which some tests in alcohol burning have been made. The standard compression ratio is 3.94 to 1. With this ratio the power fell off 5 to 10 per cent with alcohol as compared to kerosene and the consumption more than doubled. By raising the compression to a ratio of 4.95 to 1, the power increased 20 to 25 per cent over that on kerosene and the economy increased to about 1.25 lb. alcohol per b.hp.hr., as compared to 0.75 lb. of kerosene. The Case tractor engine uses 0.7 to 0.8 lb. kerosene per b.hp.hr. with 70 lb. compression and 1.12 lb. alcohol per b.hp.hr. with the compression raised to 125 lb.

Secor, giving figures for tests of the Rumely engine with 90 lb. compression, states that it used in tests made in Esthonia 0.784 lb. alcohol per b.hp.hr. as against 0.607 lb. per b.hp.hr., using kerosene, and the same compression pressure.

The Avery Co. report an increase of one-third in power in a tractor engine using alcohol as compared to gasoline, this increase presumably resulting in large part from increase in compression. The alcohol consumption is given at 1.6 lb. per hp. hr.

Horning states that engines built by the Waukesha Motor Co. develop 49 to 51 hp. on American gasoline, 44 hp. on American kerosene, 57 hp. on 93 per cent alcohol and 61 hp. on Borneo gasoline, the compression ratio used in each case not being stated.

Smooth Running with Alcohol Fuel

All authorities appear to agree that the use of alcohol fuel results in a much smoother operation of the engine than with gasoline and that detonation does not occur, as it often does with gasoline when the compression ratio is no higher than 4 to 1.

In reports from England recently received in this country, W. R. Ormandy, chairman of fuel committee of the Imperial Motor Transport Council (of Great Britain), states that detonation with alcohol does not occur with compression ratios up to 8 to 1, and pre-ignition does not occur with 6 to 1 ratios even when running for long periods with maximum power output of the engine. This agrees with findings of Ricardo, whose reports indicate that with alcohol pre-ignition occurs at lower compression pressures than detonation.

Other findings in Ormandy's recent report may be summarized as follows:

"There was no evidence whatever of corrosion in the engine. Power and efficiency are increased by the low temperature of the circulating water and supplying heat to the carbureter reduces power. Increase in water content of the alcohol up to 10 per cent by volume is an advantage especially in very high compression engines. Under all conditions of throttle or mixture alcohol requires the spark more advanced than with gasoline or benzol and much more advanced with weak mixtures."

Ricardo and others have noted that the range of com-

bustible mixtures is much greater with alcohol than with gasoline and other fuels. For this reason it is possible to vary the power of an engine through a considerable range by varying the mixture proportions. This can be done to some extent with gasoline, but to a much greater extent with alcohol. In the test with the Waterloo single cylinder engine, referred to above, it was found possible to decrease the power output 50 per cent by simply making the mixture leaner. When this is possible the use of the throttle can be avoided, within the range in question, and this permits of higher economy at part load than can be secured by the use of the throttle only, the mixture proportions remaining the same. Further information as to the mixture proportions which can be used with various compressions in alcohol engines is needed.

One of the marked advantages resulting from the use of alcohol as compared to gasoline is the absence of carbon deposit. Engines which carbonize badly in short periods when using gasoline have been run on alcohol for months without trouble from carbon deposit.

Cracking Processes

The process of cracking fuels which are not sufficiently volatile for use in automotive engines, and thus making them fit for such use, is used widely by the large refineries in this country, with the result that the available supply of motor fuel has been materially increased. According to the Bureau of Mines, practically all the cracked gasoline produced to date in this country has been made by the Burton process. On account of the desirability of having other processes available, the bureau has undertaken to obtain data regarding the more important chemical and physical factors controlling the formation of gasoline from less volatile fuels. The results of this investigation has been published in the form of Technical Paper No. 258, by E. W. Dean and W. A. Jacobs, entitled "Production of Gasoline by Cracking Heavier Oils," published by the Bureau of Mines. It is beyond the scope of this article to present in detail the results of this research work, these results being primarily of interest to the refiner rather than to the automotive industry. It may be pointed out, however, that some hundreds of patents have been taken out on various cracking processes and that the claims made for the bulk of these have yet to be proven by tests on a commercial scale. Furthermore, the few processes which have been tried in a relatively small commercial way, have yet to prove conclusively their merit over the Burton process in large scale operation. In some of them the yield of gasoline is admittedly very high, but other factors such as the renewal of the catalytic agent or of parts of the equipment employed, or the high fuel consumption, etc., are serious obstacles to be overcome.

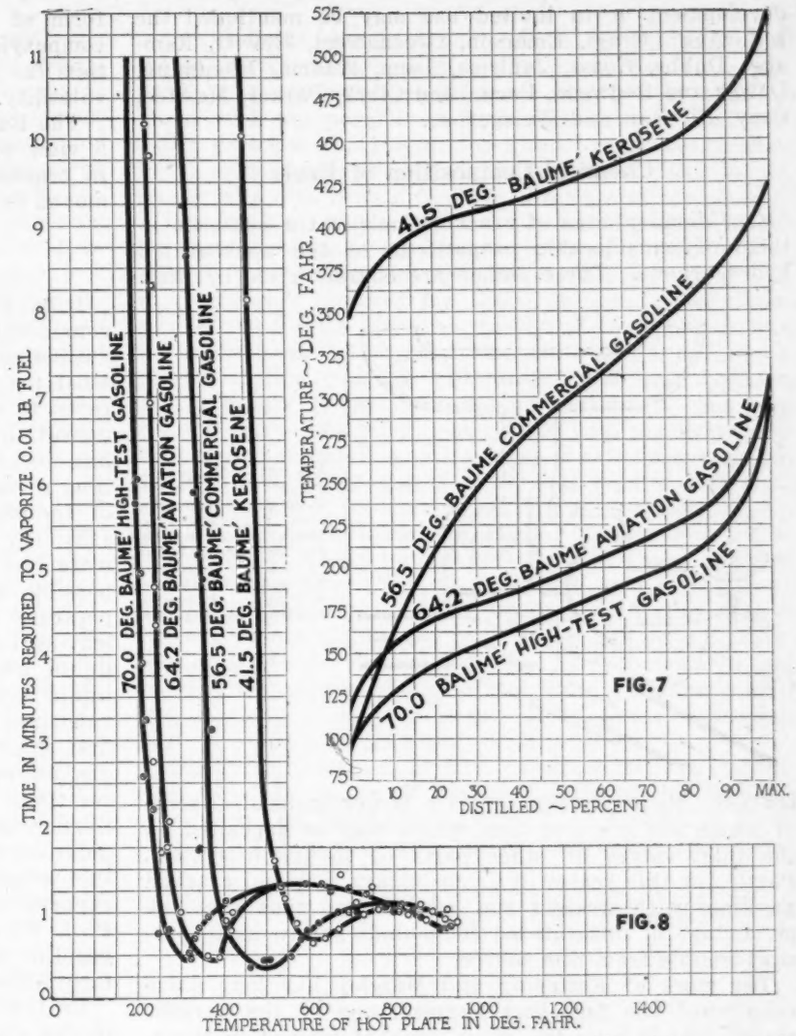


Fig. 7—Distillation curves of fuels tested by Berry and Kegerreis. Fig. 8—Curves showing time required for evaporation of 0.01 lb. of same fuels on a plate maintained at the temperature noted. Fig. 9—Effect of change in fuel-air ratio upon the temperature of the exhaust gases. Fig. 10—Relation between load and temperature of exhaust gas at different speeds

On the other hand, there is sufficient evidence of success in some quarters to warrant the hope that new and improved processes will in time materially augment the gasoline supply, possibly making it of higher average grade than at present, so that the burden of more efficiently using our available supply of motor fuel may require less of a change in engine type than has been anticipated in some sources. Nevertheless, it must not be forgotten that any new process, however promising, is certain to require many years for its introduction on a scale sufficiently extensive to have any marked effect upon the motor fuel supply as a whole. Progress is being made and is certain to continue, especially in view of the fact that the demand for fuel promises to continue to increase at a higher rate than the supply increases, thus causing a rise in price and greater incentive to secure a higher yield of motor fuel from the crude.

Among the cracking processes now said to be under

development or in limited use may be mentioned the following: Cross, Emerson, Greenstreet, Hewitt, Ramage, Dubbs, Coast, Jenkens, Isom, Adams, Flemming, Dewar and Redwood, Bacon and Clark, Parker, McAfee, Gray, Rittman and Weisgerber.

Chemical Composition of Fuels

One disadvantage of cracked fuels is the presence in them of considerable proportions of the unsaturated hydrocarbons. These olefins are characterized by their tendency to polymerize or form larger molecules, some of which are gums or tars, which may be deposited on the inlet valves or other parts of induction system. Partly for this reason it is customary to blend cracked gasolines with straight run gasoline and thus keep the percentage of unsaturated compounds so low as to prevent trouble from this source.

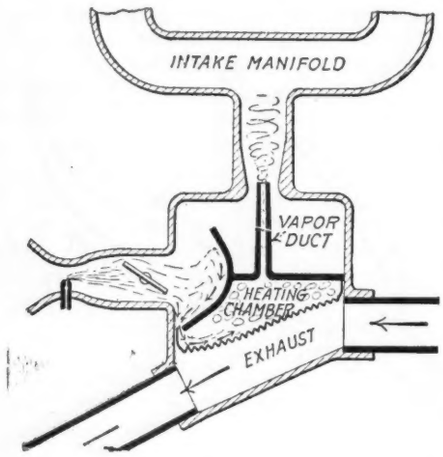


Fig. 11 — Diagrammatic sketch of type of inlet manifold suggested by Mock as a means for preparing fuels of low volatility for use in an engine without excessive heating of the air

The work of Kettering and Midgley has long since established the fact that hydrocarbons of the paraffin series, which have the chain type of molecular structure, and compose the bulk of the gasoline sold in this country east of the Rocky Mountains, are more prone to detonation, or detonate at lower pressures, than other hydrocarbons of the naphthene series which have the saturated ring structure and are present in considerable proportions in gasoline made from California crude. It has also been established that fuels of the aromatic series: benzol, toluol and xylene, will withstand still higher pressures without detonation, while the alcohols stand the highest of all. These findings have been verified by the work of Ricardo, whose reports were published under the heading, "The Influence of Various Fuels on Engine Performance," in these columns last year. The General Motors Research Corp. is continuing its investigations with a view to finding a so-called "dope," which when added to gasoline will decrease its detonating tendency. Many such substances have been found, but so far as the public is aware none of them are commercially producible in sufficient quantities to treat any large proportion of the gasoline sold in this country, even though the refiners were disposed to cooperate by adding them to the motor fuels which they produce.

Prof. Robert E. Wilson, director of the Research Laboratory of Applied Chemistry of the Massachusetts Institute of Technology, is conducting a series of investigations on motor fuels which deals chiefly with the effect of the chemical constitution of the various fuels upon their properties and behavior in internal combustion engines. This work is not to be carried out by studying actual combustion in engines, but will take the form of physio-chemical research into the effects accompanying the use of automotive fuels. The only results thus far made public will be treated under the head of volatility.

The Bureau of Mines is making an investigation with a view to learning what the gum-forming constituents in cracked gasoline are and how they can best be removed from commercial fuels.

Volatility and Vaporization of Fuels

It has long been known that the volatility of a fuel has considerable effect upon its suitability for use in automotive engines, but it has not been known definitely to what temperatures it is necessary to heat air-fuel mixtures to secure complete vaporization or prevent condensation once the fuel is vaporized. Professor Wilson has done some interesting and important work along this line, a complete report of which appears in the Journal of Industrial and Engineering Chemistry for October, 1921. By distilling gasoline and at the same time adding more fuel to maintain a constant level in the flask, it is possible after a time to arrive at an equilibrium temperature at which time the composition of the vapor leaving the flask is the same as that which enters. The liquid which then remains in the flask represents the liquid which is in equilibrium with the completely vaporized fuel, or that which would be condensed out first upon cooling the air mixture. Fig. 3 shows the distillation curves of three fuels and of their equilibrium solutions. The average boiling point of all the equilibrium solutions is about the same as the 85 per cent point on the distillation curve of the original fuel, and this temperature is of most importance in indicating the vaporization and distribution characteristics of the fuel. Prof. Wilson concludes that representative present-day gasoline has no inherent limitation to make it particularly difficult to obtain complete vaporization.

Prof. Wilson has also done important work in respect to the quantity of heat necessary to vaporize various fuels. Fig. 4, plotted as a result of this work, shows graphically the total heat required in the case of two fuels, gasoline and kerosene, sold under the trade name of Socony, to raise them to certain temperatures. It is interesting to note that, although the latent heat of vaporization of kerosene is lower than that for gasoline, the total heat required for making a combustible mixture is greater for kerosene on account of the fact that it must be raised to a higher temperature in order to get it into the air stream in truly vaporized form.

Ricardo, in the reports of research work already referred to, devotes considerable space to the subject of latent heat of vaporization and its effect upon engine performance, and gives tabular data concerning the latent heat of vaporization of various hydrocarbons. The following, among other conclusions, are drawn by Ricardo:

Latent Heat of Fuels

There is evidence that, except for fuels in the alcohol group, all fuels boiling below 392 deg. Fahr. are completely evaporated before the commencement of the compression stroke. Therefore the absolute temperature at the commencement of the compression stroke is dependent upon the amount of external heat applied and the latent heat of evaporation and almost independent of the temperature of the charge during its entry into the cylinder and the volatility of the fuel. From this it is concluded that, with any given amount of preheating, provided it is not excessive, the volumetric efficiency, and

therefore the power output, will vary directly with the latent heat of the fuel. Except for the alcohol group, the variation in latent heat is not large. In the case of alcohol, the higher latent heat and the larger proportion of fuel to air, as compared to gasoline and benzol for example, results in increased power. There was clear evidence that in the case of the alcohols, evaporation continued throughout the compression stroke, resulting in a nearly isothermal compression, a lower temperature of the cycle and a slightly higher thermal efficiency.

In this connection it is interesting to note the following comments made by a careful student of Ricardo's work and a man who has himself been closely identified with research along similar lines (see Fig. 5):

"We believe the result of greatest value from Ricardo's work has been the demonstration that the energy available from unit volumes of chemically combining mixtures of air and practically all liquid fuels are identical within about 2 per cent and that when these fuels are used in any given engine with a given expansion ratio, when the compression ratio is not high enough to produce detonation with any of the fuels, the power output and thermal efficiency are independent of the fuels used. The apparent exceptions to this conclusion are the two kerosenes and the alcohol group. Each of these, however, requires a different application of heat for proper operation. The kerosenes give identical M.E.P.'s with the lighter paraffins, aromatics and naphthenes, but lower thermal efficiency, thus indicating incomplete combustion either because of incomplete vaporization within the cylinders, which is unlikely, or because the maximum power mixture is considerably (15 per cent) richer than the maximum power mixture for the lighter fuels.

"In the case of the alcohols, although both the indicated thermal efficiency and mean effective pressure are higher than the paraffins, aromatics and naphthenes, the percentage increase in mean effective pressure is greater than the increase in thermal efficiency and therefore the combustion is probably incomplete, due to the use of maximum power mixtures which are considerably richer than the chemical combining mixtures. The increase in mean effective pressure is undoubtedly due to an increase in weight of air entering the cylinder and probably were the comparisons made on the basis of energy output per pound of air used, but little difference in the performance of the alcohols would be found."

It is generally recognized that ease of starting, especially in the case of a cold engine, depends to a considerable extent upon the presence of low boiling point fractions in the fuel, but, so far as we are aware, there is no definite data on the basis of which it is possible to predict with certainty either the proportion of volatile fractions needed to effect a start or the temperatures at which these fractions must distill off, although Professor Wilson has developed a means for comparative measurement of the effective starting volatility of different fuels.

In discussing factors which govern ease of starting before the American Petroleum Institute, Professor Wilson stated that starting volatility depends upon the lower part of the distillation curve, but not upon the initial *point*, and to illustrate this he compared three fuels which have almost the same boiling point: alcohol, benzol and a hypothetical fuel consisting of 60 per cent hexane (boiling point 154 deg. Fahr.) and 40 per cent heptane (boiling point 208 deg. Fahr.). By plotting the vapor pressures against the reciprocal of absolute temperatures of these three fuels on a logarithmic scale as in Fig. 6, substantially straight lines whose slopes are determined by the heat of vaporization of the fuels are obtained. Since the fuels have the same boiling point, the curves cross at a pressure of 760 mm., but the lower vapor pressures corresponding to the leanest mixture which will ignite are the more important, and it will be noted that the vapor pressure of alcohol drops off more rapidly than that of benzol and the paraffin in hydrocarbon fuel. To give vapor pressure of 11 mm. the alcohol must be 27 deg. Fahr. warmer than the paraffin hydrocarbon. This is one reason why it is more difficult to effect a start on alcohol.

The paraffin hydrocarbon and the benzol require about the same richness of mixture for ignition to become possible, but on account of its lower molecular weight the vapor pressure required for alcohol is about three times as great as for the other two fuels, and this again is unfavorable to ease of starting. A third reason for alcohol's poorer starting characteristics is the fact that, because of its higher latent heat of vaporization it causes a greater degree of cooling upon contact with the airstream. In the case of gasoline this cooling is said to amount to about 27 deg. Fahr. as against 122 deg. Fahr. for alcohol. The curves show, for example, that if the paraffin fuel in question has a given ease of starting 28 deg. Fahr., the benzol would have to be heated to 39 deg. Fahr., and the alcohol to 156 deg. Fahr. to give equal ease of starting. This illustrates the inadequacy of a specification which depends upon initial boiling point as a means of indicating ease of starting. Professor Wilson has succeeded in developing an apparatus intended to measure effective starting volatility of various fuels. It is described in the *S. A. E. Journal* for January, 1922, p. 20.

The light fractions in the gasolines Ricardo tested were found to consist of hexane, cyclohexane or benzine or mixtures of these hydrocarbons. He appears to have proved, however, that the "vapor pressure is indicative

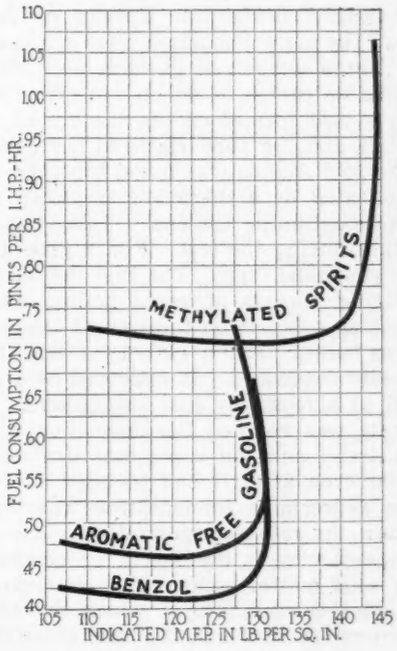


Fig. 12 — Relation between fuel consumption per i.hp. hr. and indicated M.E.P. for three fuels tested by Ricardo

of the readiness of the fuel to start from cold," a factor which has not escaped attention in other quarters.

The influence of heat added to the charge upon vaporization, starting and related phenomena has been the subject of much discussion and experimentation, but the fundamental factors involved have received far too little consideration. The quantity of heat required, the optimum temperature, location and area of heating surface and factors which control the rate of supply of heat to the heating surface are not well understood and but little reliable data appears to be available on these subjects.

O. C. Berry and C. S. Kegerreis have done some work

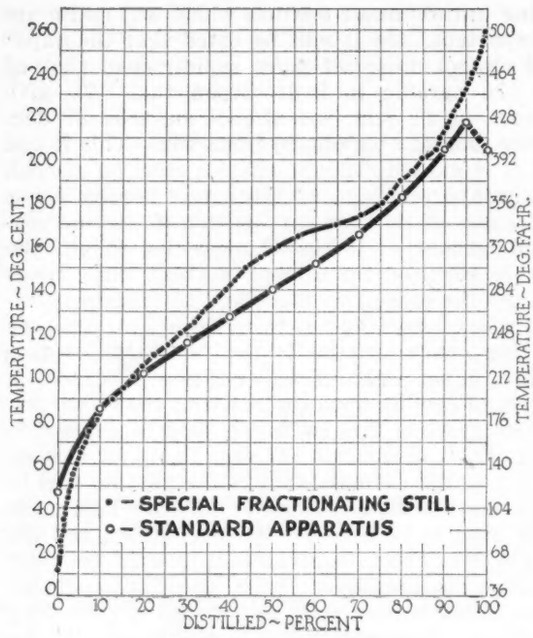


Fig. 13—Comparison of distillation curves of same fuel made respectively with the Tice fractionating still and the present standard apparatus. The differences are considerable and are said to be highly important

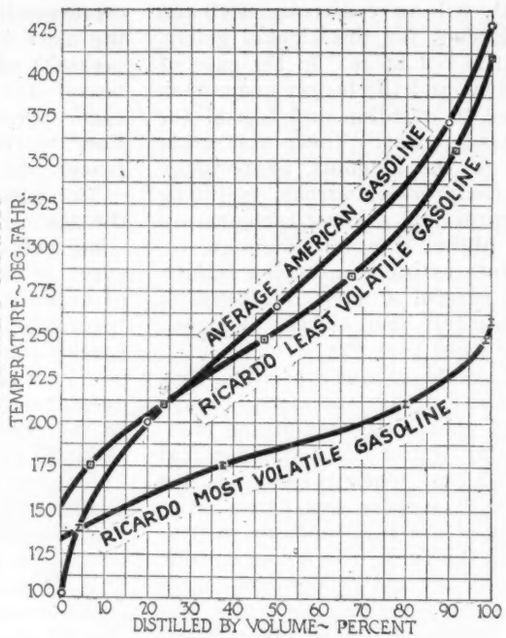

TEMPERATURE ~ DEG. FAHR.
DISTILLED BY VOLUME ~ PERCENT
AVERAGE AMERICAN GASOLINE
RICARDO LEAST VOLATILE GASOLINE
RICARDO MOST VOLATILE GASOLINE

Fig. 15—Distillation curves of the average gasoline marketed in this country and the gasolines of highest and lowest volatility covered by reports of tests made by Ricardo

intended to determine the rate of fuel evaporation from a surface heated to various temperatures, and also the effect of various factors on the temperature of exhaust gases. The results of these tests were reported in a paper presented before the Society of Automotive Engineers and the more important ones are summarized below:

Three samples of gasoline and one of kerosene, the distillation curves of which are given in Fig. 7, were placed in a well formed on the surface of an electrically heated plate and the time required for complete vaporization of the fuel sample was noted together with the temperature indicated by a thermometer placed in a well adjacent to that containing the fuel. This temperature was held constant during the test. Fig. 8 gives the results of the test in graphical form. The fuel showed evidences of cracking during periods of rapid boiling and a deposit of solid matter was left on the wall of the well. When the liquid was boiling from a wetted surface, the vapor was wet and easily condensed. It appeared as a fog as it was carried off in a relatively cool atmosphere. When the spheroidal state was reached the deposition of solid matter ceased entirely, and the vapor was dry and almost invisible so that even after it had traveled a few feet in a cool pipe no appreciable condensation was apparent. The curves show the rate of vaporization. The highest rate recorded in each case is the one in which cracking and deposition of solid matter occur. It is consequently concluded that a higher temperature at which the rate of vaporization is slower but in which the spheroidal state is reached is the best.

Tests made in an engine running at 1000 r.p.m. and half load gave the following results in respect to the temperature of the exhaust gases as measured by a thermocouple placed near the outlet of the exhaust manifold.

Varying the temperature of the cooling water from 70 to 210 deg. Fahr., measured at the water outlet from the jacket, had but little effect upon the exhaust gas temperature, which remained almost constant at about 1250 deg. Fahr. The variation was less than 50 deg. Fahr. from this mean.

The variation in temperature of exhaust gas with change in mixture proportions is shown by the curve in Fig. 9. The effect of change in load at various speeds of the engine is shown by the curves in Fig. 10. The maximum difference in temperature between light and full load is 270 deg. Fahr. at 300 r.p.m., and this difference decreases at higher speed to only 110 deg. Fahr. The tests show a variation in temperature as between low and high speed which ranges from 300 to 1300 deg. Fahr. at low loads and from about 600 to nearly 1500 deg. Fahr. at full load, hence the difficulty in maintaining any desired temperature of an exhaust heated vaporizing surface.

F. C. Mock of the Stromberg Motor Devices Co. is conducting experiments for the purpose of determining the heating areas, temperatures and other conditions of vapor generation necessary for the use of fuels ranging from aviation gasoline to fuels of low volatility known as distillate, and also the common alcohols. Mock states that he has already demonstrated that it is possible to secure better operation with the heavier of these fuels than the average motor car shows with gasoline, except in the matter of detonation, which he concludes can be taken care of by the use of water or alcohol. These fuels are being used at temperatures lower than is commonly believed necessary for efficient use of gasoline. The detailed results of these tests have not yet been given out, but Mock has expressed the view that by developing means for separating liquid fuel from the airstream, passing it to an exhaust heated chamber, and after it is vaporized returning it to the charge entering the inlet manifold, after the manner shown diagrammatically in Fig. 11, it will be possible to overcome many difficulties now encountered in efforts to better utilize present-day fuels.

This method of handling relatively non-volatile fuels is not new. It is in fact being used, with many variations in mechanical arrangement and design in the case of several vaporizing systems marketed in this country, and further tests along similar lines are being made by various concerns, among them being the Autocar Co. The method does not necessarily involve, as so many, especially British investigators, appear to assume, a high temperature of the incoming charge, for only the fuel is heated, while the air, at least in many excellent systems, is heated in a secondary way by admixture with the fuel after the latter is vaporized. This may result in condensing the fuel, but the fog thus formed is composed of such fine particles as to handle much like a true gas, and because of the large surface presented by the fuel particles, they are readily vaporized prior to combustion by contact with the hot piston, cylinder walls and residual products of combustion in the cylinder.

Mixture Proportions

The proportions of fuel to air have a very marked effect upon the power and economy of an engine and much excellent work has been done with a view to determining the

optimum ratios both for maximum power and maximum economy. The work of P. S. Tice and O. C. Berry, records of which have appeared in these columns, and that of the Bureau of Mines contain some excellent data in this regard, and a review of these and other sources of information along this line is given in a paper by W. S. James of the Bureau of Standards, read at the summer meeting of the S. A. E. last year. Berry has since done additional work on behalf of the Wheeler-Schebler Carburetor Co. with a view to learning the mixture requirements of engines under various conditions of steady running, acceleration, temperature, manifolding and quality of fuel. These include a series of tests showing the relation between the content of CO_2 in exhaust gas and the power and efficiency of the engine under various speeds, loads and mixture proportions. Records of these tests have not yet been made public. The effect of the temperature of fuel and air on the mixture proportions has also been investigated and are said to have made it clear that thermostatic control of the carburetor can be made of great practical value.

P. S. Tice, in charge of the Carbureter Division of the Stewart-Warner Speedometer Corp., who has done much valuable work in connection with problems relating to fuel economy, has recently made a study of the effect of pulsating flow upon carbureter metering and upon the measurement of air consumption of engines, and is now preparing a report on this subject.

Ricardo has included in his research work record of some experiments which, he says, demonstrate that "maximum power is always developed (with fuels other than the alcohols) when the mixture strength is at or near that giving complete combustion, and points to the curves given in Fig. 12 as proof of this fact. Other investigators have reached different conclusions, but so far as we recall most if not all of them used multiple cylinder engines in their determinations, and it is possible that the imperfect distribution which it is difficult to avoid in such engines accounts to some extent for the difference in the conclusions arrived at. In the case of alcohol fuel, however, Ricardo finds that the power output "increases as the mixture is enriched, and continues to so increase until the mixture strength is at least 20 per cent more than that required for complete combustion." This he attributes to the high latent heat of vaporization of alcohol and the relatively large increase in specific volume resulting from combustion.

Distillation Tests of Fuel

The distillation test of various fuels has long since taken the place of hydrometer testing which at one time was supposed to give some indication as to the value of fuels for engine uses, but is now recognized as being of secondary importance except when considered in combination with other known characteristics.

It is generally understood that the lower the distillation curve of a fuel, the more readily it is vaporized, but certain points on the curve are of special significance, as has already been pointed out in connection with the work of Prof. Wilson. Distillation tests are, as a rule, made with an apparatus consisting of an engler flask, a heating element, condenser, thermometer, etc., set up and operated in accordance with specifications laid down by a Government Committee on Standardization of Petroleum Specifications and published in Bulletin 5 of the U. S. Bureau of Mines. According to P. S. Tice, who has made a close study of this apparatus and of tests made with it, the apparatus has the following undesirable characteristics: Lack of control of still head temperature, use of an unnecessarily rudimentary still head, too high rate of distillation, too large increments per cut and lack of provision for conserving earliest distillates. Because of the faulty apparatus and methods, Tice states that two men using the same apparatus cannot consistently check results. Furthermore, the initial boiling point indicated by it may be as much as 70 deg. Fahr. too high and the end point too low by as great an amount, while direct recognition of any one of the numerous substances of which the fuel is made up is difficult to recognize either as to character or amount.

As a result of experimental work with fuel fractionating apparatus and other experience in work of this character, Tice has developed a special fractionating still which is said to incorporate the following essentials of design: Close and consistent regulation of the temperature of the still head walls, intimate thermal contact between vapors

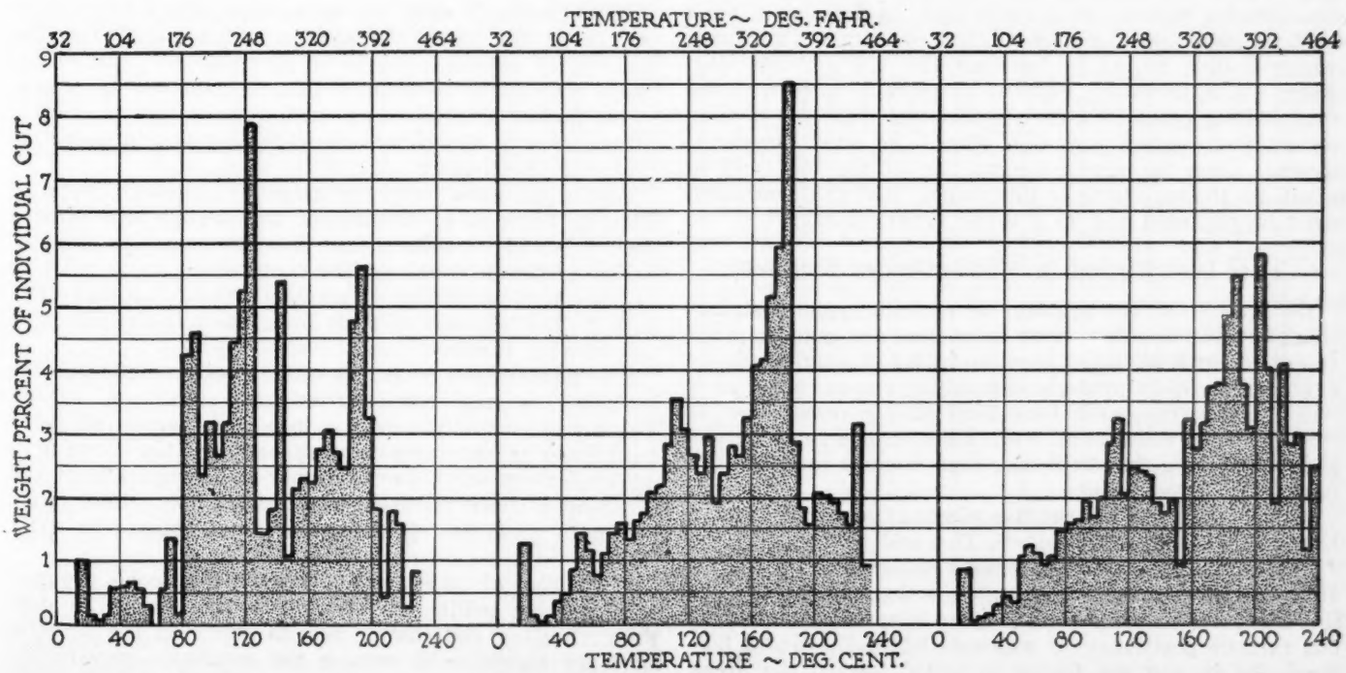


Fig. 14—Cumulative plotting of distillation data obtained by use of the Tice fractionating still on three brands of gasoline sold most extensively in and about Chicago

and condensate, minimum temperature gradient across still head section at any level, and sufficient space and time intervals between still and side tube. On account of limited space available here, it is planned to give a detailed description of the Tice distillation apparatus in a later issue of AUTOMOTIVE INDUSTRIES, but the appended distillation curves, Figs. 13 and 14, show clearly the advantage of this apparatus over the present standard type in more closely recording the distillation characteristics of the fuel. The conventional plotting used in Fig. 13 shows the boiling range of the fuel but gives little idea as to the substances contained or the quantities in which they occur. The differential plots in Fig. 14, in which the percentage of each cut is treated separately, shows the approximate number of fuel substances present, the approximate percentage and quantity in which they occur and the approximate boiling points of each substance. The data presented in Fig. 14 is representative of the three brands of gasoline sold most extensively in Chicago, the samples having been obtained at filling stations there on March 8, 1922. Fuel A is said to be a "straight run" gasoline.

The U. S. Bureau of Mines has, for some three years, been making a semi-annual gasoline survey. Representative samples of gasoline are collected in nine large cities in various parts of the country, and these are subjected to the tests required under the Government specifications. The latest survey, completed in March of this year, shows that the average quality of gasoline sold is almost identical with that sold a year earlier. The average initial boiling point is given as 102 deg. Fahr. and the average end point at 430 deg. Fahr. The average distillation curve is shown in Fig. 15 in comparison with similar curves for the gasolines of highest and lowest volatility tested by Ricardo as shown by his reports published in these columns last year. It is interesting to note that all except the initial part of the average curve of American gasolines is well above that for the least volatile gasoline tested by Ricardo, a fact which makes it more than ever apparent that gasoline used in the British Isles is much more readily volatilized than our own. This, of course, accounts to a considerable extent for the relative ease with which it is possible to efficiently utilize British as compared to American gasoline.

One of the interesting conclusions drawn by Ricardo as a result of his research work reads as follows: "There is considerable evidence to indicate that, in the case of most 'natural' gasolines, the more valuable constituents are those whose boiling points lie between the 176 and 356 deg. Fahr. It is, therefore, quite as undesirable to restrict the final boiling point of a fuel to 300 deg. Fahr. as it is to permit it to exceed 392 deg. Fahr. So much, however, depends upon the actual composition of the fuel, and so great are the variations in this respect that this conclusion must be regarded only as a broad generalization."

Fuel Distribution in Multi-cylinder Engines

On account of the problem of securing equal distribution of fuel in an engine with more than one cylinder much recent research work has been conducted on single-cylinder engines, thus quite properly eliminating one variable factor which has too frequently been overlooked in research work. The variables which control distribution are so numerous and complicated that little has been done to establish the laws which govern them.

Among the most informative pieces of research work in this field is that done by P. S. Tice and published in the *Journal of the Society of Automotive Engineers* for March, 1921, in which are given photographs showing the streamline characteristics for various types of manifold and various throttle positions. It was noted that the liquid filaments lie in and are forced to travel toward the areas of low pressure. Some work along similar lines has been done at the Bureau of Standards. Tests of this character are desirable as indicating the manifold areas to which heat can be applied to best advantage. O. C. Berry, among others, is collecting as much information as other work permits regarding the factors which control distribution, but so far as we are aware there is little if any basic work being done along this line. Prof. C. E. Lucke of Columbia University is studying the effect of manifold design and other factors on fuel utilization, but no results of this work have as yet come to our notice.

Ricardo states that "uniformity of mixture strength supplied to each individual cylinder of any group drawing from one source of supply depends primarily upon the design of the induction system generally and to a surprisingly small extent upon the nature of the fuel. A really well designed and efficient distribution system appears to maintain nearly the same uniformity of mixture strength on all fuels . . . though defects are more accentuated the lower the volatility of the fuel." He says further that distribution is the factor about which least is known to-day, while it exerts a more important influence than almost any other.

Effect of Fuel on Lubricant

The character of the fuel plays an important part upon the quantity of fuel which passes the pistons and is dissolved in the lubricant. Much fuel reaches the cylinder in a liquid state even when the induction system is highly heated, in some cases, and unless this fuel, which is usually composed of the less volatile ends is evaporated by contact with the hot piston, cylinder walls and residual gases in the cylinder, much of it finds its way into the crankcase and dilutes the lubricant.

Prof. Wilson, in connection with other research work already mentioned, is undertaking to measure the relative solubilities of various types of fuels in various lubricants, with a view to minimizing troubles from dilution. Work done by other investigators has shown that certain oils are affected less than others by contact with fuel which finds its way into the crankcase, but findings in this connection have not yet been made public.

Effect of Various Factors on Fuel Economy

Much research work has been done with a view to determining the numerous factors which affect the fuel economy of automotive engines and complete vehicles, but much remains to be done in this regard, both in respect to the factors themselves and in the application of existing information in designing new apparatus and in operating that now in existence.

Again we must refer to extensive research work of Ricardo. Some of his findings in this regard have already been referred to. Others may be summarized as follows:

For maximum economy, the compression ratio must be as high as it is possible to employ without inducing detonation. The tendency of fuels to detonate is the outstanding limiting factor.

The temperature of jacket water does not influence the indicated thermal efficiency to any significant extent. There was some slight gain in indicated thermal efficiency with lower jacket water temperatures, but the increase in mechanical efficiency due to higher wall temperatures and consequent lower viscosity of lubricant more than offset any gain from low jacket water temperatures in most cases.

In the case of fuels—except those in the alcohol group—with narrow boiling range, and boiling below 26 deg. Fahr., heating the charge has no effect on the thermal efficiency except as it reduces the maximum permissible compression pressure, but the power is decreased. The

thermal efficiency is somewhat increased by heat addition in the case of alcohol, but the power is decreased. This applies to single cylinder engines. In the case of multiple cylinder engines, where the question of distribution enters, heating the charge often increases thermal efficiency.

When the ignition is properly adjusted the indicated thermal efficiency remains nearly constant down to 40 per cent load, but if the ignition remains set at the same advance required for best performance at full load, the indicated efficiency falls off in substantially direct proportion to the decrease in load.

It is evident, of course, that fuel economy is affected by numerous other factors, some of which have already been mentioned in connection with the work of Ricardo, Berry, the Bureau of Standards, and others, but perhaps the most obvious loss is one that is preventable, or largely so, and yet so prevalent that it escapes attention in a vast majority of cars used, especially in this country. We refer to the loss incident to incomplete combustion, resulting in large part from the use of mixtures which are much too rich in fuel.

Experiments made by the writer and published in these columns several years ago, and many other experiments along similar lines made at earlier as well as more recent date, have shown that the exhaust gas from automotive engines contains large quantities of incompletely burned carbon. Among the most extensive of these tests are those reported by the Bureau of Mines which show that from 20 to 30 per cent of all the fuel used in the average American passenger car and truck passes out in the exhaust unburned. The reason why more efficacious steps are not taken to prevent this waste it is beyond the scope of this article to attempt to explain. The resultant loss is very great, though there is abundant data on the basis of which it can be minimized if not prevented.

Friction, of course, plays an important part in regard to fuel economy, and it need hardly be said that mechanical friction should be reduced to a minimum in the interest of lower fuel consumption. Engine friction is made up of mechanical and liquid friction and pumping losses. The largest item in mechanical friction is that of pistons and rings. This friction in turn is largely dependent upon the internal friction or viscosity of the lubricant. There is considerable research data on engine friction, some of which is contained in the paper by W. S. James and his associates on the staff of the Bureau of Standards, entitled "Elements of Automobile Economy" and published in the Journal of the Society of Automotive Engineers for June, 1921. It is there shown that engine friction increases at a somewhat higher rate than the speed and is materially affected by oil viscosity (see Fig. 16). Variations in friction with change in load (manifold depression) are also given. The losses increase slightly as the throttle is opened. For maximum fuel economy with a given engine the engine speed should be kept as low as possible, pointing to advantages from as small a reduction in gear as is practicable—and the oil used should have the lowest viscosity consistent with maintenance of an oil film where it is required.

Friction in gearset, axle and other parts of the transmission have a direct effect upon economy, as do also the rolling losses in tires and the wind resistance of the vehicle. These factors are treated in several pieces of research work, some of which have been recently printed in these columns and one of which is included in an article relating to tires which appears in this issue.

An article entitled "Relation Between Fluid Friction and Transmission Efficiency," by Neil MacCoul, presented at the last annual S. A. E. meeting, gives useful data on gearset losses under various conditions of oil viscosity, load, speed, etc. The article entitled "Rear Wheel Dyna-

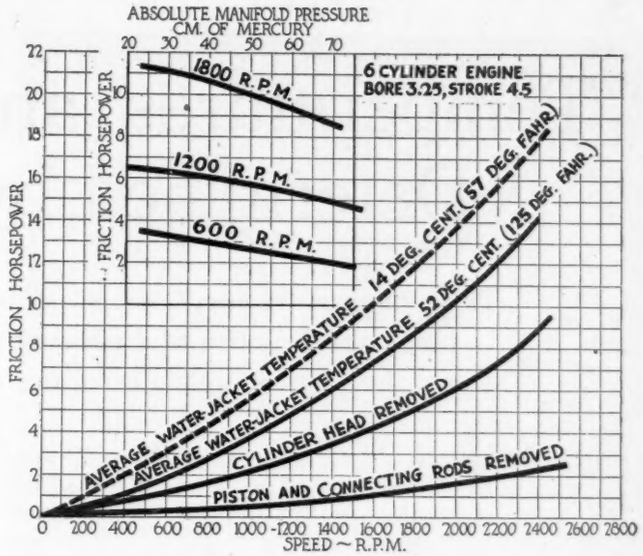

ABSOLUTE MANIFOLD PRESSURE
CM. OF MERCURY
20 30 40 50 60 70
FRICTION HORSEPOWER
1800 R.P.M.
1200 R.P.M.
600 R.P.M.
6 CYLINDER ENGINE
BORE 3.25, STROKE 4.5
AVERAGE WATER-JACKET TEMPERATURE 14 DEG. CENT. (57 DEG. FAHR.)
AVERAGE WATER-JACKET TEMPERATURE 52 DEG. CENT. (125 DEG. FAHR.)
CYLINDER HEAD REMOVED
PISTON AND CONNECTING RODS REMOVED
FRICTION HORSEPOWER
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800
SPEED ~ R.P.M.

Fig. 16—Relation between friction hp. speed and load under various conditions, as given by W. S. James

mometer Tests and Their Significance to the Engineer," based on tests made by Professor Lockwood of Yale University and printed in AUTOMOTIVE INDUSTRIES for April 20, 1922, gives much data on actual rolling resistance of various cars and trucks as well as their economy and power under conditions approximating road operation. The wide variations in friction losses and the decreased loss when using cord as compared to fabric tires is particularly noted.

Prof. W. E. Lay of the University of Michigan, and Prof. T. R Agg of Iowa State College, are investigating the rolling resistance and fuel consumption of trucks and cars on grades and level roads, while experiments made with a view to determining the actual wind resistance of vehicles are in progress at other universities. Professor Lay also has in progress some work intended to determine the effect of humidity on fuel economy.

The Bureau of Standards has had in hand for some time a series of tests the purpose of which is to measure graphically and with accuracy the performance of cars in operation on the road. Special apparatus has been designed for this purpose. It is so constructed as to give instantaneous values and to record them positively in order to minimize the number of observers required and eliminate the personal equation. The results of tests with this special equipment are to be reported at the semi-annual S. A. E. meeting next month. The apparatus includes a recording accelerometer of the liquid column type, a Republic flowmeter with special recording device, a vane anemometer with recording device arranged to measure air velocity and a Van Sicklen tachometer which is free from time lag. The temperature of the inlet and outlet cooling water, the fuel and air entering the carbureter, and the depression in the inlet manifold are measured and recorded on commercial instruments designed for this purpose. The quantity of air used is estimated by the use of a small venturi tube placed in the hot air pipe leading to the carbureter. By the use of this equipment it is hoped to secure much data which will be valuable in determining the factors which govern fuel consumption and related factors which determine car performance. While much is known regarding the performance of engines and complete chassis running under constant load in laboratory tests, there is much need for precise measurements on cars running under the actual conditions of service. Much useful data in this regard should be furnished by the Bureau of Standards tests.

Temperatures and Friction Losses Determined by Tire Research

Tire temperature increases as inflation pressure decreases. Rolling resistance of fabric tire fifty per cent greater than that of cord. Influence of wear on rolling resistance not proved.

THE manufacturers of rubber tires are confronted with technical problems of two kinds, one chemical, the other mechanical. The problems of compounding and curing rubber are essentially chemical in nature, while those relating to the building up of the carcass in such a manner as to minimize the work of flexing the walls, thereby reducing the friction loss in the tire and increasing the useful life of same, are essentially mechanical. The automotive engineer is directly interested only in the performance of tires; that is, their life under normal service conditions, their power absorption or frictional loss, and their rise in temperature in service. A good deal of research work bearing on questions such as these has been carried out during the past few years, and we are fortunate in being able to present in the following the results of two such series of researches.

Engineers as a rule do not realize what a large fraction of the power absorbed in the propulsion of an automobile is taken up in flexing the walls of the tires. This fraction of the energy of propulsion is converted into heat, and, in addition to being a direct loss, helps to cut down the useful life of the tires. It is evident, from the results of tests quoted further on, that a material increase in fuel mileage might be gained by keeping the tire inflation pressure always up to normal or even above normal. Of course, high inflation pressures are inimical to riding comfort and also to the endurance of some of the more delicate parts of the car, and what is the optimum inflation pressure in any particular case, all things considered, is certainly hard to determine.

The other class of problems coming up in connection with rubber tires is of a chemical nature, and its technicalities do not concern the automotive engineer directly, but any material progress in compounding or in methods of vulcanization of rubber which tends to either lower the cost of production or to increase the serviceability of tires should be called to his attention. Thus the automotive engineer certainly wants to know something about the organic accelerators of vulcanization which have come into use these last few years and which are the subject of a great deal of research work just now, both in Europe and in this country.

Temperatures of Pneumatic Truck Tires*

THE life of any pneumatic tire depends upon many factors. For large tires the operating temperature has become one of considerable importance, especially when they are used in hot climates. To obtain some information on this subject a series of experiments were conducted by the author for the Goodyear Tire & Rubber Co. The main purpose of these experiments was to determine:

1. The best means of measuring tire temperature.
2. The effect on temperature of inflation pressure, load, long runs, frequency of stops, rim size and tire size.
3. The temperature of various designs of tires.
4. Suitable means of reducing tire temperatures.

Heating of tires is due almost entirely to the flexing of the tire walls, or, in other words, it is due to hysteresis. The maximum temperature is reached when the rate of generation of heat is just balanced by the rate of its dissipation to the atmosphere. There are a great many factors which affect both of these rates, so that laboratory tests are essential if comparative temperatures are desired. These tests were all made in the laboratory at Akron with testing machines, each one comprising two 45-in. cast iron pulleys driven by an induction motor. A suitable framework allowed a known load to be supported by each tire. The pulleys drove the tires without any resistance except that due to their flexing and the slight loss due to bearing friction and air resistance.

To have a check upon the results, two different methods of measuring the temperatures were used simultaneously. One method consisted in measuring the increase in the pressure and in the volume of the air in the tire, from which the temperature may be calculated provided the initial temperature and pressure are accurately determined. The gages used to measure the air pressure were mounted on the hub of the wheel so that they rotated with the tire. They were checked daily and were also calibrated frequently by means of a dead weight tester.

Since all inner tubes have some leakage, it is necessary to determine its amount during a test and apply the proper correction to the pressure readings. The total leakage was determined for the twenty-four-hour period following the start of each run. This total leakage was then distributed on the assumption that the rate of leakage is proportional to the absolute temperature of the tube and to the square root of the pressure difference inside and outside of the tire. A special test in which the leakage was abnormally large showed that this was a reliable method of making the distribution. Suitable curves were prepared to facilitate the application of this method of correcting for leakage.

*From a paper presented before the S. A. E. Buffalo Section by Frank O. Ellenwood, Professor of Heat-Power Engineering at Cornell University. This abstract of the paper was made by Prof. Ellenwood himself.

Several methods of measuring the increase in the volume of the air in the tire were tried, but it was found that the measurement of the longitudinal tread circumference was the most satisfactory. Knowing the cross sectional dimensions of a tire the relation between the volume of the air in the tube and the longitudinal tread circumference may be determined. With this information expressed in graphical form, the temperature of the air in the tube is readily calculated for any measured increase in volume and pressure, if the initial temperature and pressure are known.

A special tire thermometer designed by the Taylor Instrument Co. was used in many of the tests. On account of the vibration of a truck wheel it was necessary to have the space above the mercury filled with nitrogen. Because of the small clearance available the thermometer had to be bent at right angles and for protection each glass thermometer was inclosed in a metal case.

Before splicing the inner tube the metal thermometer well was placed on the inside of the tube, the stem passing out through a special valve patch, and this well was then clamped in place as is done with an ordinary valve stem. The well was partially filled with oil before inserting the thermometer. The union formed a tight covering for the well, so that no oil was lost when the wheel rotated.

After calibrating these thermometers carefully it was found that the readings obtained from them when inserted in a tube were very much lower than the true temperatures as obtained by the method previously described. This difference was at first believed to be due entirely to heat conducted away from the thermometer well by the cool part of the inner tube and by the atmosphere. By making several improved types of thermometer wells it was found that much better results could be obtained. The main feature of improvement was the addition of many thin fins to the wells, thus increasing very materially the rate at which heat is absorbed from the air inside of the tube. The rate of dissipation of heat from the wells could not be changed appreciably. It was not possible, therefore, to build a well which would enable the correct temperatures to be read by these mercury thermometers when using dry air in the tube.

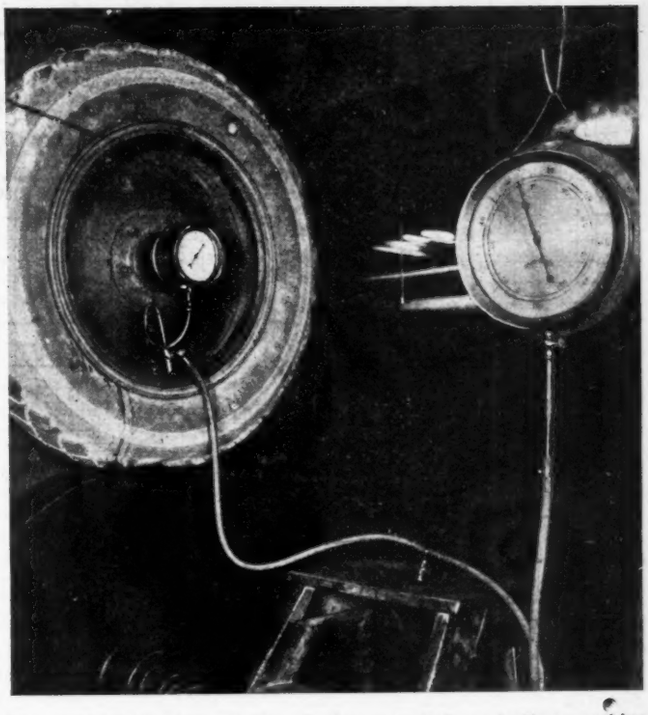


Fig. 1—General view of 40 x 8 tire mounted on testing machine. Pressure gage fastened to the hub of the wheel, and large standard test gage connected to tire for daily gage calibration

Thermocouples placed inside of the tube were next tried. Much experimental work was done in the attempt to obtain a type which would be satisfactory mechanically, electrically and thermally. The temperatures obtained from the best types of tube thermocouples were materially lower than those obtained from the calculations based on the pressure and volume. This fact combined with the low readings from the tire thermometers made it imperative that extra precautions be taken to know whether the air inside of the tube was saturated

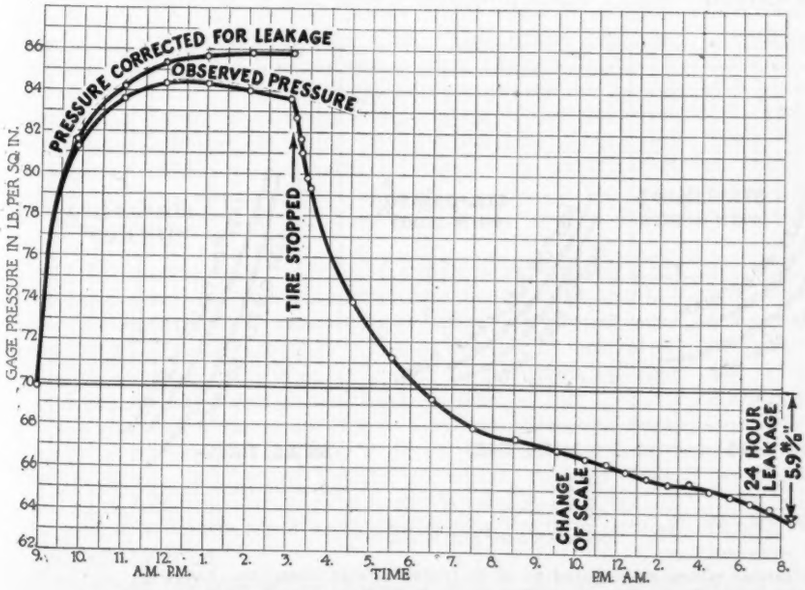


Fig. 2—Leakage data obtained from an old tube during 6 hrs of operation and the following 18 hrs. of cooling

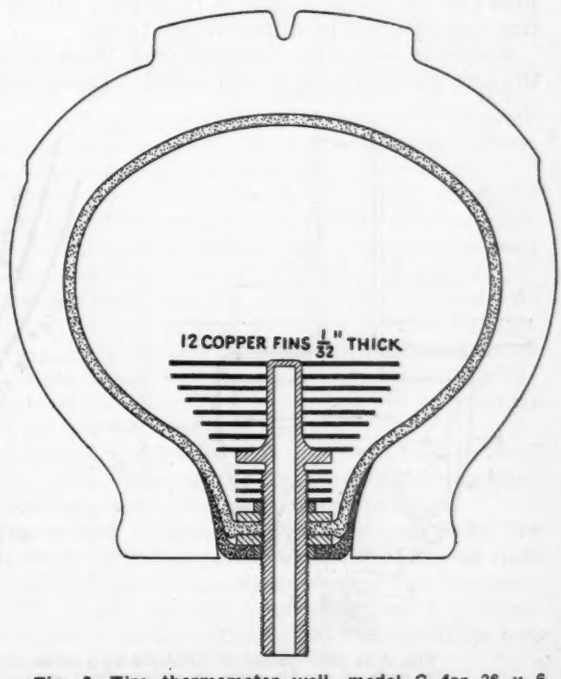


Fig. 3—Tire thermometer well, model G for 36 x 6 tires with head absorbing capacity increased by the attached fins

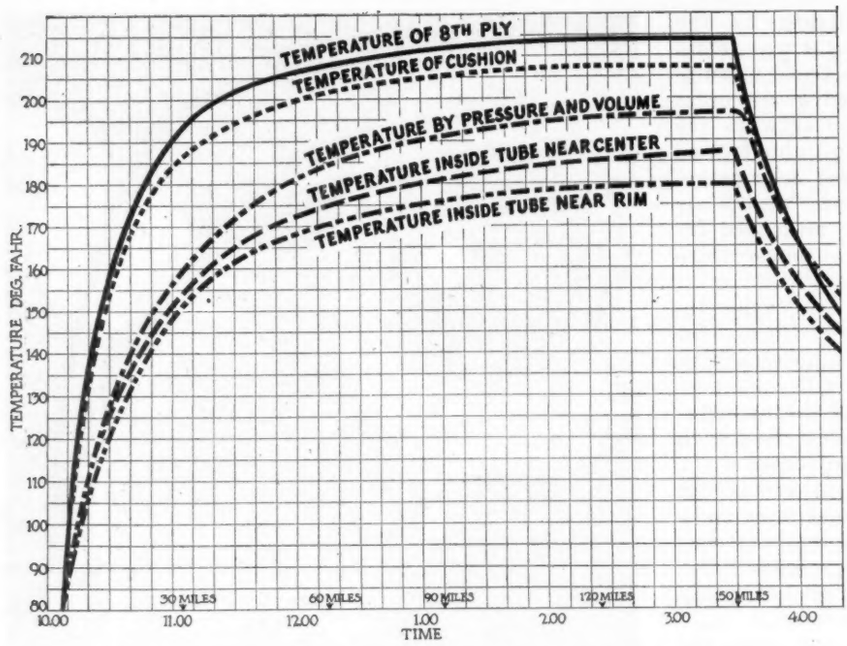


Fig. 6—Temperatures of various parts of a 40 x 8 tire as obtained by several methods. The room temperature during this test was 90 degrees F.

with moisture. To have enough moisture inside of the tube to cause saturation at all temperatures means that a different method of calculation must be used from that which is correct for dry air. That the air inside of the tube supposed to contain "dry air" did contain only a little moisture was made certain by inflating the tires with air which had been passed slowly through a special separator containing calcium chloride and also by the examination of samples drawn from the tube after inflation. Hence the temperatures as calculated for dry air were correct.

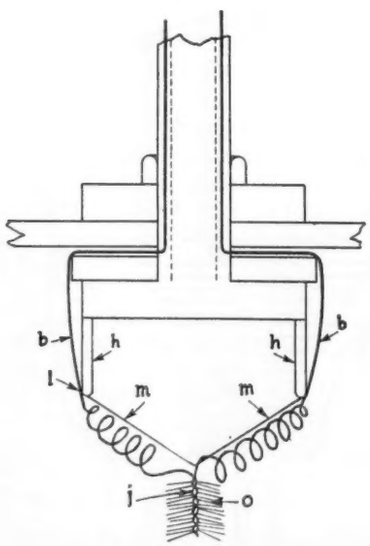
To account for the difference in temperatures as obtained from the different methods the effect of convection currents was next investigated. This was done by placing thermocouples in different places inside of the same tube and obtaining readings from each couple when the tire was stopped in different positions.

Readings were also obtained from these couples while the tire was running at full speed. These tests showed that convection currents would account for the discrepancy between the thermocouple readings and the average temperature of the air in the tube. They also explained why the tire thermometer used with the well having many fins on it still gave readings too low.

Tube thermocouples are troublesome in many ways, and, besides, it was desired to measure the temperature of the material in the hottest part of the tire. This led to the use of detachable thermocouples. They are made of very fine wire mounted on the end of a small hard rubber insulating plug, that is inserted immediately after stopping the tire, in a hole bored through the tread to the point at which it is desired to measure the temperature. The temperature indicated by the potentiometer will then rise quickly to its maximum, which is appreciably less than the temperature of the stock because of the heat conducted away from the couple. One of the greatest advantages of this method is that it enables the temperature of the stock itself to be determined. This temperature is very much higher than that of the air inside of the tube. The ease with which the couple may be renewed is another important advantage. The injury to the casing caused by the drilling of small holes is of no great importance in the case of laboratory test tires.

Before any comparative temperature tests were made the deflections of the tires under various inflation pressures were determined. The results of many different temperature tests were plotted, and in all cases it was found that it takes nearly six hours of operation for a 40 x 8 tire to reach its maximum temperature. The smaller sizes require less time.

For sections of the country having long periods of very hot weather it is desirable to have some simple means of cooling large truck tires. A very satisfactory cooling method was found to consist of putting a small amount of water inside of the tube before inflating with air. The theory which prompted trying this is as follows:



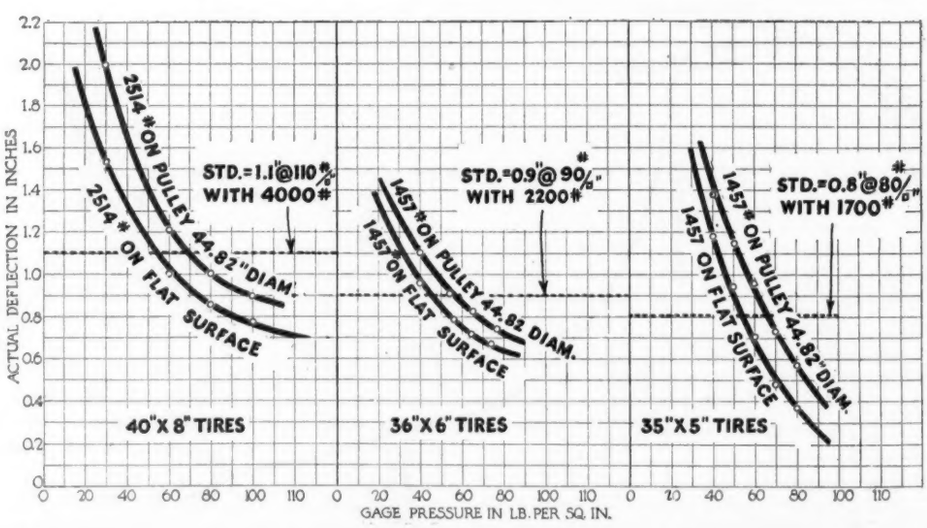


Fig. 4 (Left)—Model E. Couple at j with fine copper wires, o, soldered to it to increase heat absorbing capacity; b, coils of couple wire to reduce heat conduction from the couple; m, cotton cords supporting couple from anchor wires, l and h. Fig. 5 (Right)—Deflections of three sizes of tires having various inflation pressures when supported by flat and curved surfaces

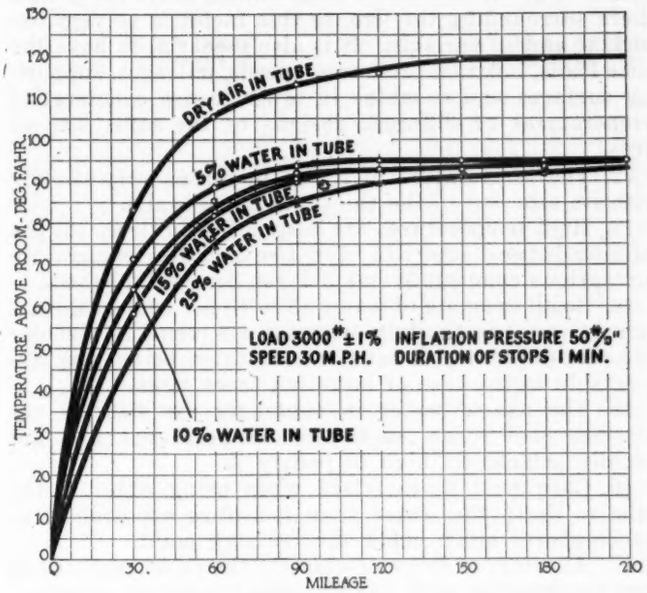

DRY AIR IN TUBE
5% WATER IN TUBE
15% WATER IN TUBE
25% WATER IN TUBE
10% WATER IN TUBE
LOAD 3000# ± 1% INFLATION PRESSURE 50#/"
SPEED 30 M.P.H. DURATION OF STOPS 1 MIN.
TEMPERATURE ABOVE ROOM - DEG. FAHR.
MILEAGE

Fig. 7—Tube temperatures resulting when various amounts of water were used in the tube

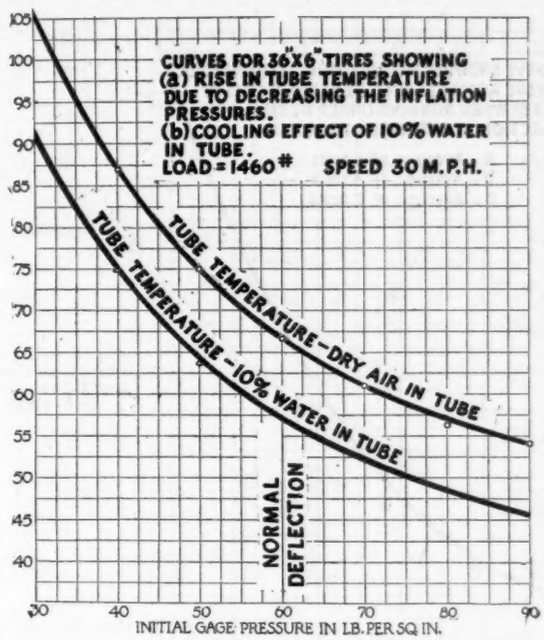

CURVES FOR 36"X6" TIRES SHOWING
(a) RISE IN TUBE TEMPERATURE DUE TO DECREASING THE INFLATION PRESSURES.
(b) COOLING EFFECT OF 10% WATER IN TUBE.
LOAD = 1460# SPEED 30 M.P.H.
TUBE TEMPERATURE - DRY AIR IN TUBE
TUBE TEMPERATURE - 10% WATER IN TUBE
NORMAL DEFLECTION
INITIAL GAGE PRESSURE IN LB. PER SQ. IN.

Fig. 8—Temperature effect of underinflation on small truck tire, "wet" and "dry"

First, a small decrease in the generation of heat may be expected because the vapor pressure will increase the total pressure inside of the tube so that the amount of flexing of the tire is reduced. This vapor pressure will be small, but it will act as a sort of safety valve because the hotter the tire the greater will be the vapor pressure. The vapor pressure increases more rapidly than does the air pressure for a given increase in temperature.

Second, the vapor may be expected to transfer heat very rapidly from the hottest parts of the tube to the cooler parts of it. As the tire rotates the water is kept in a thin band extending entirely around the tread portion of the tube. This is the hottest part of the tube and the cooling would be effected here by the evaporation of the liquid which would condense again on the cooler portions of the tube, lying next to the rim and the side walls. The very rapid circulation of the air and vapor in the transverse section of the tube is of material assistance in this transfer of heat.

Third, a cooling effect is produced on the tube by the absorption of heat by the liquid itself until it attains the same temperature as the tube. This effect depends upon the amount of liquid used, as may be seen in one of of the accompanying illustrations. It should be noted that in all cases the average temperature of the wet tube is materially lower than that of the dry tube and that the beneficial effects of the extra liquid is very small after the first three hours of the run.

The following general conclusions are drawn from these experiments:

1. The measurement of the increase in air pressure of a tire is a very accurate and reliable means of determining the average tube temperature providing proper precautions are taken to know whether the air is saturated and to have accurate measurements of pressure, volume changes, leakage and initial temperature.

2. Convection currents inside the hot tube are very large and may necessitate a large correction to any temperature measuring apparatus which records only the particular temperature at some definite region, which is small in comparison with the whole cross sectional area of the tube.

3. These convection currents are due to the variation in density of the air in contact with the hot and cool portions of the tube, combined with the forces of gravity and that due to the rotation of the wheel. The first of these forces causes the convection currents to flow in the longitudinal direction of the tube when the tire is standing still, and the second causes much stronger currents to be in a transverse section of the tube when running.

4. Tire thermometers of the type herewith described are not very well suited for any tube temperature measurements except the initial one, on account of the corrections due to the convection currents and the still greater correction due to the heat conduction to the cool part of the tube to which the well must be clamped.

5. Thermocouples placed inside the tube and mounted so that they will be held near the center of the tube are rather frail and are likely to be injured or misplaced during the splicing of the tube; they are also subject to corrections due to convection currents and require considerable care and patience to make and install.

6. Detachable thermocouples of the type herein described are easily made and used; they are quite reliable when carefully used, and they possess the very great advantage of giving fairly close to the correct temperatures of the various parts of the tire which are hottest and whose temperatures are often most desired.

7. The detachable thermocouple readings must be taken at very carefully measured intervals of time after stopping the tire as the hottest parts of the tire cool rapidly and appreciably immediately after stopping.

8. It appears likely that the detachable thermocouple should have a correction applied to its reading to compensate for the conduction of heat through the wires from the couple to the outside air. This correction has not been worked out completely as yet but will be greatest when used in holes of shallow depth.

9. The pressure in the tube does not begin to drop until a short time after stopping the tire, thus affording time to obtain accurate pressure and volume readings.

10. The pressure volume method combined with the detachable thermocouple one appears at the present time to be best suited for determining pneumatic tire temperatures, as the results are more accurate, more comprehensive and more easily obtained than those from any other methods thus far developed by the author.

11. For comparative tire temperature the results:

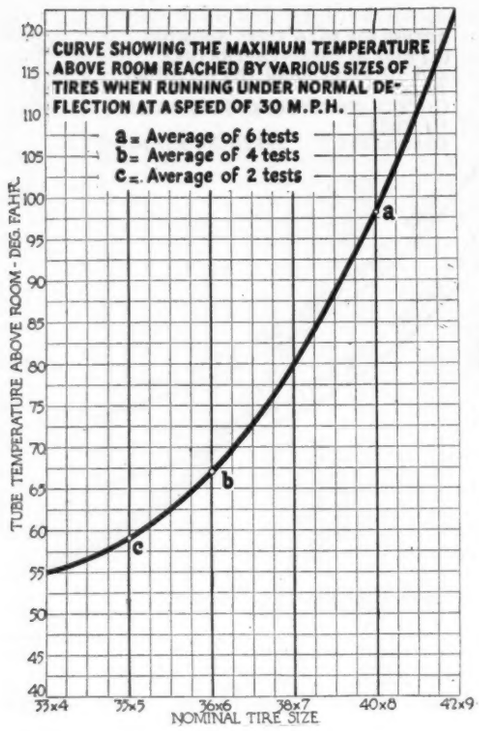


Fig. 9 — Variation of tire temperatures with tire sizes

should be given in terms of temperature above the atmosphere surrounding the tire, as this factor is so very important and so variable. It is also essential to have the same loads, inflation pressures, speeds, mileages, supporting surfaces and sunshine in order to use comparative temperatures of different designs of the same size of tires.

12. The temperature of a tire increases very rapidly with its size due to the thickness of its walls.

13. High temperatures are destructive to tires, but the relation between the life of a tire and its temperature for various compounds has not yet been established.

14. Small amounts of water (5 to 10 per cent of the air volume) used in the tube with the air result in a cooler tire, the difference in tube temperatures being very appreciable in the case of large hot truck tires.

15. The use of water in passenger car sizes is not recommended since such tire temperatures are not usually sufficiently high to justify it.

16. Care must be exercised when using water in the tube to drain the water from it before exposing it to temperatures much below the freezing point.

17. All users of tires should note the rapid increase in tire temperature with the decreased inflation pressure.

A more detailed survey of the results of these tests is not possible in the limited space available. The accompanying charts, however, bring out briefly the more important results.

Tire Friction Losses

CONSIDERABLE research work on the power losses in various kinds of tires has been done by Prof. E. H. Lockwood at the Mason Laboratory, Sheffield Scientific School, Yale University. The influence of load and inflation pressure on the friction losses was studied for both kinds of pneumatic tires, the fabric and the cord tire, while in the case of the solid rubber tire the variation of the tire losses with increasing wear or reduced thickness was investigated.

Tests of fabric tires were made on three different sizes of the same make, viz., 32 x 4 in., 33 x 4½ in., and 35 x 5 in. For each test load and inflation three different speeds were used, but it was found that changes due to speed were very slight and that speed could be eliminated as a factor. The rolling resistances of the three tires under different loads and with different inflation pressures are given in Table I.

From the data given in this table the conclusion may be drawn that the rolling resistance of a fabric tire may be increased more than 50 per cent by lowering the inflation pressure from 90 to 30 lb. per sq. in., and 25 per cent by lowering it to 50 lb. per sq. in. The total car resistance, of course, will not be increased in this same ratio. In Fig. 1 are shown rolling resistance-load curves for the three sizes of tire for different inflation pressures. It is noteworthy that the so-called "curves" are straight lines and also that for the same inflation the "curves" for the different tire sizes show the same relation between load and rolling resistance. Hence the rolling resistance depends solely on the load and not on the size of tire. The rolling resistance of fabric tires when fully inflated may be represented by the following formula—

$$R = 0.018\,L - 3.0,$$

where R is the rolling resistance in pounds and
L is the load on the tire in pounds.

A simplified way of giving the average rolling resistance of the tires tested is to say that it amounts to 15 lb. per thousand.

Dynamometer tests of cord tires show that their rolling resistance is approximately one-third less than that of fabric tires. The following figures, based on tests made on Fisk and Goodyear tires, are presented as typical of the test results.

TABLE I—ROLLING RESISTANCE OF FABRIC TIRES
(Speed, 20-40 m.p.h.)

32 x 4 in. non-skid; weight of tire, 19.5 lb.; outside dia., 32.8 in.

	Load 460		Load 700		Load 975	
Inf.	lb.	p.c.	lb.	p.c.	lb.	p.c.
30	8.03	186	14.45	165	22.3	163
55	5.35	124	10.6	121	16.8	121
80	4.33	100	8.78	100	13.7	100

33 x 4½ in. non-skid; weight of tire, 23.5 lb.; outside dia., 33.7 in.

	Load 585		Load 935		Load 1285	
Inf.	lb.	p.c.	lb.	p.c.	lb.	p.c.
30	9.05	124	18.4	152	27.7	145
45	8.65	118	15.6	130	23.0	121
65	8.65	118	14.2	118	21.2	111
90	7.32	100	12.03	100	19.1	100

35 x 5 in. non-skid; weight of tire, 33.5 lb. outside dia., 36.0 in.

	Load 750		Load 1050		Load 1650	
Inf.	lb.	p.c.	lb.	p.c.	lb.	p.c.
40	12.7	123	19.8	128	37.0	148
55	11.4	109	17.6	115	32.4	129
70	10.5	102	15.9	103	28.2	113
90	10.3	100	15.4	100	25.1	100

COMPARATIVE ROLLING FRICTION OF FABRIC AND CORD TIRES
(At speeds of 20-40 m.p.h.)

Tire size, 32 x 4 in.; inflation pressures, 30-80 lb. p. sq. in.; loads, 460-975 lb.

Average of 54 readings for fabric tires, 11.3 lb. = 100 per cent.

Average of 54 readings for cord tires, 7.6 lb. = 67 per cent.

Tire size, 33 x 4½ in.; inflation pressures, 30-90 lb. p. sq. in.; loads, 585-1285 lb.

Average of 72 readings for fabric tires, 15.2 lb. = 100 per cent.

Average of 72 readings for cord tires, 9.06 lb. = 60 per cent.

Tire size, 35 x 5 in.; inflation pressures, 40-90 lb. p. sq. in.; loads, 750-1650 lb.

Average of 32 readings for fabric tires, 21.1 lb. = 100 per cent.

Average of 32 readings for cord tires, 13.45 lb. = 64 per cent.

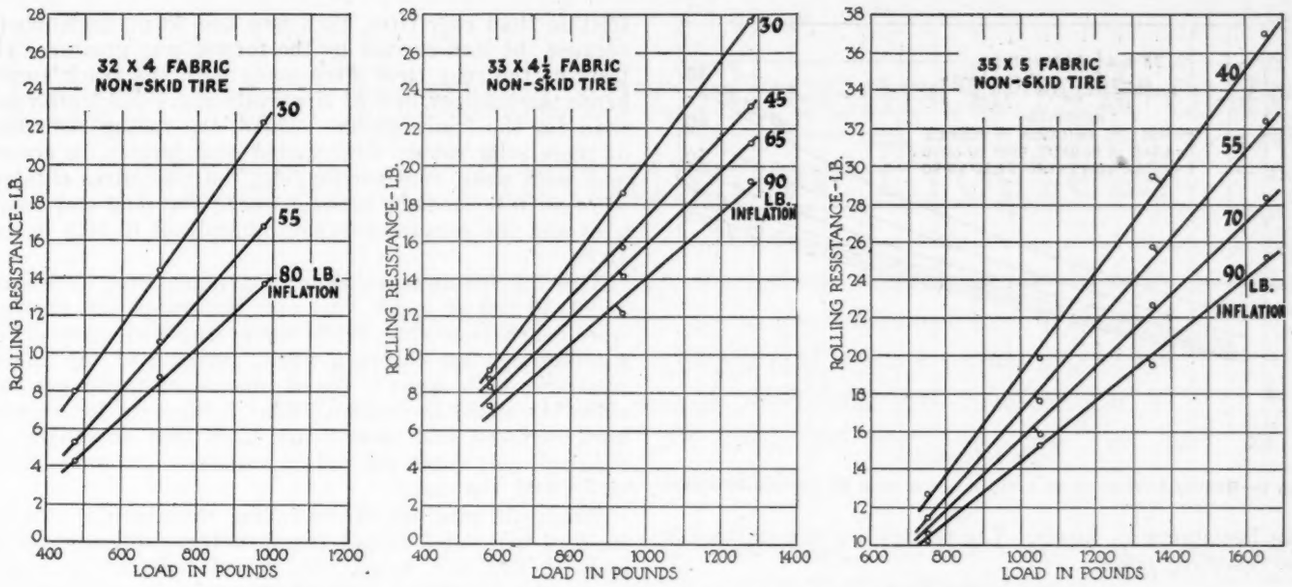


Fig. 1—Rolling resistance of fabric tires as affected by size, load and inflation pressure

By plotting curves of the test results it was found that the proportion of the rolling frictions is about the same for all inflations. A valuable feature of the cord tire is that the rolling resistance is low even for low inflations. For instance, with an inflation pressure of 65 lb. the rolling resistance is 11.5 lb. and for a pressure of 90 lb. it is 11 lb. In Table II are given the rolling resistances of 33 x 4½ in. cord tires for three speeds, three loads and four inflation pressures. It will be noticed that after the inflation reaches 60 lb. per sq. in. there is little further decrease in rolling resistance, and that high inflation pressure is not essential to efficient operation of cord tires. Within the limits covered by the experimental work the rolling resistance for any load and inflation pressure may be obtained from the following equation—

$$R = \left(\frac{L - 200}{100}\right) \times \left(1.06 + \frac{(90 - P)^2}{7000}\right)$$

R = rolling resistance; L = load; P = inflation pressure. Limits, load from 500 to 1300 lb.: Inflation, 30 to 90 lb.

For a normal inflation pressure of 60 lb. this equation simplifies to

$$R = 0.012\,L - 2.0,$$

in which, it will be noted, the constants are such as to give a result exactly 50 per cent greater than given by the equation for fabric tires.

Tests on solid rubber tires were made at intervals from 1919 to 1921 on ¾ to 2 ton trucks. It was found that solid tire resistance could be measured by the jacking-up method, and that in general the resistance was intermediate between the resistances of fabric and cord pneumatic tires under the same load. Later on tests on the chassis dynamometer at Mason Laboratory were made in co-operation with the Committee for Research on Trac-

TABLE I—TABLE OF FRICTIONAL DISTRIBUTION IN THE CHASSIS

Measured on the Mason Laboratory Dynamometer

Number of cylinders	4	4	6	6	6	8	8
Bore x stroke, in.	4⅛ x 4½	3¾ x 6¾	3¼ x 4	3¼ x 4½	3½ x 5	2⅞ x 4½	3⅛ x 5⅛
Weight, front, lb.	1,360	1,850	1,250	1,350	1,585	1,495	2,010
Weight, rear, lb.	1,650	2,250	1,450	1,460	1,815	1,735	2,400
Weight, total lb.	3,010	4,100	2,700	2,810	3,400	3,230	4,410
Tires, front, size	32 x 4	32 x 4½	32 x 4	32 x 4	33 x 4	32 x 4	35 x 5
Tires, front, kind	1 fab.-1 cord	cord	cord	1 fab.-1 cord	cord	cord	cord
Tires, rear, size	32 x 4	32 x 4½	32 x 4	32 x 4	33 x 4	32 x 4	35 x 5
Tires, rear, kind	cord	cord	cord	1 fab.-1 cord	cord	cord	cord
Rolling resistance, front tires	23.2	25.3	9.5	22.8	14.6	16.4	21.0
Rolling resistance, front bear.	4.4	2.4	7.4	3.2	3.9	4.0	6.2
Rolling resistance, front total	27.6	27.7	16.9	26.0	18.5	20.4	27.2
Rolling resistance, rear tires	19.0	30.0	16.0	20.3	22.8	25.2	23.5
Rolling resistance, rear bear-tr.	14.0	14.0	10.0	14.6	27.8	13.8	26.5
Rolling resistance, rear total	33.0	44.0	26.0	34.9	50.6	39.0	50.0
Rolling resistance, front and rear	60.6	71.7	42.9	60.9	69.1	59.4	77.2
Rolling resistance, tires only	42.2	55.3	25.5	43.1	37.4	41.6	44.5
Rolling resistance, bear. and trans.	18.4	16.4	17.4	17.8	31.7	17.8	32.7
Rolling resistance, engine, 20 m.p.h.	47.5	69.0	34.0	27.4	74.4	88.0	47.5
Rolling resistance, total, including engine	108.1	140.7	76.9	88.3	143.5	147.4	124.7

TABLE II—ROLLING FRICTION OF 33 x 4½ CORD TIRES

Average Values for Seven Ribbed and Non-Skid Tires

Inflation	Load 585				935				1285							
	30	45	65	90	30	45	65	90	30	45	65	90	585	935	1,285	Av.
Speed, m.p.h. 20	6.03	5.16	4.68	4.17	10.99	9.04	8.21	7.49	17.39	14.06	12.16	10.87				
Speed, m.p.h. 30	6.33	4.98	4.70	4.29	11.75	9.76	8.34	8.01	18.17	14.71	12.32	11.30				
Speed, m.p.h. 40	6.91	5.26	4.65	4.54	12.37	10.01	8.43	8.22	19.01	14.89	12.64	11.70				
Speed, m.p.h., aver.	6.42	5.13	4.68	4.33	11.7	9.60	8.33	7.9	18.19	14.55	12.37	11.29	5.14	9.38	14.10	9.54

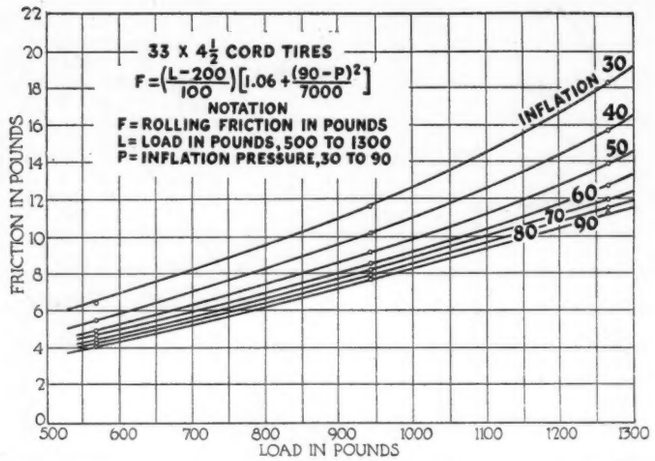


Fig. 2—Rolling friction of 33 x 4½ in. cord tires at various inflations

tive Resistance on Roads. The results are summarized in the following table:

FRONT TIRES, NEW

36 x 4	single	Load 583 per inch width	Resistance 21.7 lb. per 1000
36 x 5	single	Load 466 per inch width	Resistance 19.0 lb. per 1000
36 x 6	single	Load 375 per inch width	Resistance 20.2 lb. per 1000
36 x 7	single	Load 375 per inch width	Resistance 19.0 lb. per 1000
Average		Load 450 per inch width	Resistance 20.0 lb. per 1000

FRONT TIRES, WORN

36 x 5	single	Load 466 per inch width	Resistance 15.5 lb. per 1000
36 x 6	single	Load 375 per inch width	Resistance 16.5 lb. per 1000
36 x 7	single	Load 375 per inch width	Resistance 16.2 lb. per 1000
Average		Load 400 per inch width	Resistance 16.1 lb. per 1000

REAR TIRES, NEW

40 x 6	dual	Load 285 per inch width	Resistance 18.0 lb. per 1000
40 x 6	dual	Load 275 per inch width	Resistance 15.7 lb. per 1000
40 x 12	single	Load 275 per inch width	Resistance 14.0 lb. per 1000
40 x 12	single	Load 275 per inch width	Resistance 15.8 lb. per 1000
40 x 12	single	Load 275 per inch width	Resistance 19.0 lb. per 1000
Average		Load 275 per inch width	Resistance 16.5 lb. per 1000

REAR TIRES, WORN

40 x 6	dual	Load 285 per inch width	Resistance 12.5 lb. per 1000
40 x 6	dual	Load 255 per inch width	Resistance 11.0 lb. per 1000
Average		Load 270 per inch width	Resistance 11.8 lb. per 1000

Several conclusions are apparent from these figures: First, the partly worn tires roll with less friction than new and more resilient tires, the difference being from 20 to 25 per cent. Hence increased cushioning must be paid for by increased power. Second, front tires showed more friction than rear tires, both new and worn, undoubtedly because the load carried by the former was greater. The tests of the rear tires were made with the truck empty, hence the load per inch of tire width was considerably less than for the front wheels. Third, the rolling resistance of these solid rubber tires varied considerably, in accordance with wear, construction, etc., but the values obtained were all intermediate between those for cord and fabric tires and the general average figured out to 16.0 lb. per 1000.

Tire friction measurements by dynamometer were made at 20, 30 and 40 m.p.h., and over this range the readings were nearly constant. When the averages of many different readings are taken, a slight increase of the rolling resistance with speed is found, amounting to 6-8 per cent when the speed is doubled. This holds only for smooth, hard surfaces, and there is no doubt that on rough, uneven and soft roads the rolling resistance increases materially with the speed.

Thirty-six readings of the rolling resistance of 33 x 4½ in. cord tires with ribbed tread, of three different makes and for different speeds, loads and inflation pressures, gave an average value of 8.83 lb., while the same number of readings taken on non-skid tread tires of the same size under the same conditions showed an average of 9.58 lb., an increase of 8 per cent. This increase is probably caused by the greater compression of the rubber under the load, and undoubtedly varies with the shape of the non-skid formations. A so-called non-puncture type of thick-walled tube showed increased rolling resistance of 5 to 10 per cent, while a tube protector consisting of a thick endless pad lying between the tube and casing caused an increase in rolling resistance of 7 per cent in a 33 x 4½ in. casing.

Tests on giant pneumatic tires as used for trucks showed that their rolling resistance is somewhat greater than would be expected from the equations developed for the smaller sized cord tires.

As far as pneumatic tires are concerned, no influence of the state of wear and age on the rolling resistance could be proved. With solid tires the resistance decreases as the tire wears out. There seems to have been a general improvement of pneumatic tires as regards rolling resistance during the past four years, amounting in the case of cord tires to about 10 per cent.

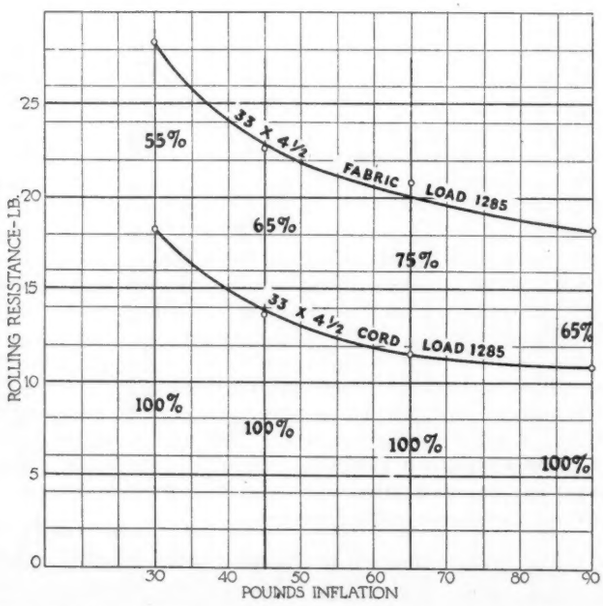


Fig. 3—Typical rolling resistance curves of cord and fabric tires under constant load and varying inflation

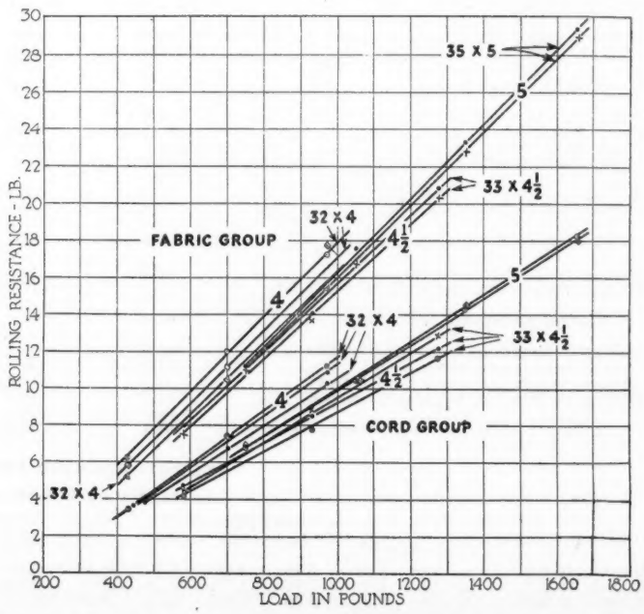


Fig. 4—Rolling resistance of cord and fabric tires compared, at 65 lb. inflation pressure

Highway Transport Research Is Foundation of Automotive Progress

Industry must form habit of thinking of highway vehicle always in relation to highway. Traffic surveys have been sporadic, but are being improved in character and usefulness. March and April months of average traffic. Trucks overloaded. Fuel consumption related to road design.

By H. S. Fairbank*

MOST of the problems of highway transport center about the motor truck. The question of its proper place is one of the most important questions to be answered. What are the clear fields of the truck, the railroads, the electric roads, the waterways; in what parts of the field are they competitors; where are they allies? Able investigators are working on the problems presented by the motor truck, but it must be admitted that, as yet, the vagueness of the results of their researches is more or less disappointing to the many people who are waiting for information of practical usefulness.

In the passenger-carrying field the automobile used to be accepted as largely a pleasure vehicle, the lineal descendant of the horse and carriage. But, of late, we have begun to see a commercialization of the passenger car in the form of the motor bus, and we shall now have to ask ourselves the same questions with regard to its relations to the other carriers as we do in the case of the truck and commodity haulage. The point is that we are not interested only in the motor vehicle and in highway transportation—that is, we should not be—but in transportation as a whole. All existing agencies—even the horse—have their proper field and we shall profit most by finding that field for each as quickly as possible. In attempting to do that we find ourselves in a maze of criss-cross relations which will take some of our best thought before they are untangled.

AT the outset it will be well to form the habit of thinking of the highway vehicle—motor truck, automobile or horse-drawn wagon—always with the highway. The two constitute highway transportation. They are as inseparable as the railroad train and its rails, the vessel and its stream. Each affects and limits the other and together they have their effect upon the other systems.

We must learn the relation of the road to the vehicle. And it is precisely in this field that the bulk of the investigation thus far centers. Highway engineers have been feeling for that relation for more than a decade. Forced by circumstances to build roads without a proper conception of all the factors involved, they have taken what time they could for a study of traffic by means of the traffic census.

Most of the early traffic counts were made in advance of the improvement of particular roads with the idea of determining the kind of road required. The fact that the traffic which used the road after it was completed was totally different from that revealed by the preliminary count and that some of the roads, in consequence, were pretty badly battered was a source of considerable annoyance to the highway engineers. But out of that experience has come a knowledge of one of the cardinal laws of highway traffic which was certainly not appreciated before if indeed it was understood at all. That law is that traffic flows to the better road.

One of the earliest States to set about the business of a traffic census in a systematic way was Maryland. The State Roads Commission began some five or six years ago the counting of traffic monthly on each completed contract section of the State highways. The counts were made by the maintenance patrolmen. They distinguished between several classes of horse-drawn vehicles and light and heavy motor vehicles. The data collected were put to no immediate use, but carefully were filed away, and those files have become a veritable mine of useful information.

BECAUSE the records cover the traffic on the whole State highway system Dean A. N. Johnson, of the Engineering College, University of Maryland, has been able, by plotting the averages for a year, to produce a traffic map of the State on which by varying the width of the lines representing the roads he pictures the varying intensity of traffic on all parts of the system.

Another fact of importance that is clearly brought out by the Maryland data is the seasonal variation of the traffic. Taking the Baltimore-Washington road as an example to show the usefulness of the data, the averages of the records for this road show that traffic is at a maximum each year from June to October, inclusive, with the peak in October. November, December, January and February are the months of light traffic, and March and April bring close to average volumes of traffic to the road. From the middle of June to the middle of October the daily traffic is about 135 per cent of the average daily traffic for the year on this particular road, and from November to February it is less than 75 per cent of the annual average.

Between these data for one particular road in Maryland and the statistics of all the railroads, as compiled by the American Railway Association it is possible to draw some interesting comparisons.

*Senior highway engineer, Bureau of Public Roads.

Both on the railroads and the highway the months of March and April stand out as the period of average traffic.

For our latitude it is safe to say that a single traffic census taken during these months, whether for a railroad or a highway will come as close as possible to indicating the average daily traffic for a year. Qualitatively, the periods of lean and heavy traffic on railroad and road coincide. October is the big month on each, and February is the month of lowest ebb.

Truck Traffic Variable

IT is when we come to compare the variation of traffic quantitatively that we find the one outstanding difference between the railroads and the road. The railroad has an almost uniform flow of traffic the year round. The peaks and valleys come along at the same seasons as on the road, but they are not nearly as high or as low. October's railroad traffic, for example, is only 116 per cent of the monthly average. On the road it is 140 per cent. In February traffic on the railroad drops only to 85 per cent of the monthly average, while on the road it falls to but little over 60 per cent. Traffic on the road the winter through, that is from November to February inclusive, is 73 per cent of the average for the year, and in the summer—from June to October inclusive—it is 135 per cent. For the same periods on the railroads the percentages are 95 and 106.

These facts should suggest a number of things to all who are trying to raise highway transportation to a higher level of efficiency.

Bear in mind that the road selected for the foregoing comparison is one of the most noted roads in the country, a road that is in shape for travel at all times of the year. Take the highways of the country as a whole, or even the principal highways, and the comparison would be decidedly more favorable to the railroad.

H. R. Tolley and L. M. Church of the Bureau of Public Roads, have thrown some light on the average passability of our roads for motor trucks by their researches conducted by means of farmer's questionnaires in the Eastern and Corn Belt States. Each farmer was asked to specify the kind of roads over which his truck traveled and the number of weeks during the year when the roads were in such condition on account of mud or snow that the truck could not be used. Twenty-nine per cent of the farmers in the Eastern States reported that their trucks ordinarily travel only on dirt roads, 46 per cent reported that the roads they use are part dirt and part improved, and the remainder said that the roads they operated over were all improved. On the average there were 10.7 weeks during the year when the men with all-dirt roads could not use their trucks at all, those with part-dirt roads managed to operate during all but 7.8 weeks and the men whose roads were wholly improved were entirely laid up only 3.8 weeks, probably by snow.

In the Corn Belt the record was less favorable. Eighty per cent of the farmers reported only dirt roads, 14 per cent said they had partly improved roads, and only 6 per cent had totally improved highways to operate over. So it is not surprising that the average number of weeks during which operation was impossible in this section was 8.4 as compared with 7.7 weeks in the Eastern States.

Tolley and Church uncovered some other facts of importance in their correspondence with farmers and we will come back to them later. For the present, since this is a story of research and only by way of example a record of the results of research, let us revert to the traffic census and see what has been done with that useful instrument.

Most of the traffic records have been made by the State highway departments, and most of the work has been sporadically done. With one or two exceptions it has not been done with any very definite purpose in view other than to record some information which might later prove interesting to examine. As a result not many of the numerous records that have been made offer an attractive field for the analyst.

The first traffic census taken in this country for any extended period was made in Illinois in 1906-7, where the traffic was counted at some seventy-odd stations continuously during a two-year period on an average of four times a month. The data collected are chiefly valuable from an historical standpoint.

The valuable work done by Maryland has already been noticed. The Iowa highway department has made a contribution along a slightly different line. At the time they made their study the purpose in mind was to settle the question, then a subject of considerable debate, as to whether the roads should be built principally to accommodate the so-called farm-to-market traffic or the through or tourist traffic. To answer this question Iowa made counts at 47 stations in 1917 and 87 in 1919 and their data are mainly useful for the classification of the traffic by source and origin.

The results for the two years expressed in the same terms are given in the following table:

Per Cent of Total Traffic

Year	Farm-to-town, Per cent	Interurban, Per cent	Interstate or tourist, Per cent
1917	46.6	46.9	6.5
1919	47.1	46.1	6.7

Before-and-after improvement counts made in other States have served principally to prove the utter valuelessness of traffic counts made before the improvement of a road to indicate the form the improvement should take, and to illustrate the principle of selection which runs through the whole fabric of our transportation system, according to which the traffic takes the easiest and best road from source to destination.

California Investigations

WITHIN the past two years, however, traffic censuses of a different order have been taken in several parts of the country, which have produced some really important data and which without question represent the highest development of the traffic census as a research instrument, lacking only the continuity of the Maryland records.

The first of these studies was made by the Bureau of Public Roads in California, in connection with an investigation of the accomplishments of the State highway commission made at the request of the commission in 1920.

One hundred and three stations were selected and counts were made at each for intervals varying from one to eleven days, and for 16 hours each day. The traffic classification distinguished between light and heavy automobiles, motor trucks of four capacity groups, passenger buses, horse-drawn vehicles and extra-heavy vehicles. The average of the counts for the whole State shows that in numbers of units the highway traffic of California is predominantly a passenger automobile traffic, vehicles of that description constituting nearly 83 per cent of the total. In point of tonnage the commodity traffic plays a more considerable part, but it is not to be compared to such traffic as some of the Eastern highways carried during the war years. Not more than one-third of the tonnage of traffic in California is in trucks, whereas during the war such roads as the Belair road in Mary-

land carried truck tonnage in excess of 50 per cent of the total.

SINCE the stations selected in California covered practically the whole road system of the State it was possible to plot the counts for each station in traffic diagrams which show the variation in traffic on the various parts of the system. The diagrams, like similar ones plotted in Maryland, bring out very clearly the influence of the cities and towns. The typical form is a series of peaks and valleys with a peak at each town depending in height upon the size and character of the town and a valley in between depending in depth upon the distance between towns, the character of the towns and the character of the intervening rural sections.

These traffic diagrams, or traffic profiles as they might be termed, have a meaning which has not been unriddled because no one, so far, has made a determined effort to obtain the collateral economic data with regard to the towns and the country traversed which is needed to show why one city causes a higher peak than another, or one rural section maintains a higher level than another. If traffic censuses are to be genuinely helpful it is the firm belief of the writer that sooner or later this effort will have to be made.

Until it is made the traffic census will give a fair picture of an existing condition, but it will be a practically useless instrument in the solution of the main question, which is always, what traffic can be expected, not what is the traffic now. The farmer's parallel problem—the productivity of soil — is never solved by a weighing of crops only, no matter how many yields are weighed. It is only when the yield is related to the analysis of the soil that scientific agriculture adds anything of value to almanac farming.

In addition to the character and volume of the traffic and an insight into the laws of local traffic variation, the California investigation produced interesting data with regard to the daily and hourly variations. Sunday was shown to be the day of greatest travel with an average traffic approximately 1.7 times the average week-day travel. Saturday came next and Friday's traffic was the lowest of the week. On the average day the traffic was found to be a minimum at 6 a. m. when the counts were begun with a subordinate peak at 11 a. m. and a maximum peak at 5 or 6 p. m. both on Sundays and week-days. Is this variation to any extent controllable, or is it the inevitable result of the individualistic character of highway traffic? Will it ever be practicable to spread highway traffic over the week and the day and the season to a degree approaching the constant and regular use of rails?

These are not academic questions. The efficiency of the highways is bound up in them. Such very practical considerations as the widening of roads are dependent upon the answers we find. And who is to say now that some such control may not be possible? In commodity haulage there is already an apparent trend from individualism to co-operation and specialized corporate transportation service. When we get right down to brass tacks, how many of us would care to say definitely that highway passenger transportation will remain indefinitely the unorganized affair it now is? These are some of the questions which remain to be answered. Shall we wait until they answer themselves, or shall we try to discover where we are going before we get there?

There is other food for thought in the California investigation—much of it—for the interested reader, but space will not permit a discussion of it here. The primary purpose of the investigation was to appraise the service value of the State road system, and there is much that is suggestive and a great deal that is definitely informative in the methods adopted by the investigators no less than in the valuable results of their investigations.

The Connecticut survey, another experiment of the Bureau of Public Roads, in which it co-operated with the State highway department, dealt solely with the traffic. Problems of the road as a structure had no place in it. It was strictly an analysis of traffic. The roads selected for the investigation were the Boston Post road, upon which the counts were made at Greenwich, and the Hartford - Springfield road, which was studied at a point near the Massachusetts line.

HERE is a comprehensive survey of all the significant studies that are being made in the field of highway transport. The activities are reviewed in an interesting, non-technical story that gives briefly a number of interesting facts about highway transport research that every automobile man will want to know.

The field covered includes traffic surveys, operating cost investigations, determination of relation between vehicle and highway design, store-door delivery and accident studies. The field of the motor truck as a transportation medium is being defined by the results of these investigations.

THE traffic passing these two points during fourteen-day periods was counted and weighed. The vehicles were measured, their tire equipment was noted, their speed was observed, the character of their cargo was recorded and their drivers were questioned as to the length of their trip.

Most striking among the results of this census is its revelation of the prevalence of overloading. Every third truck was found to be loaded beyond the rated capacity of the truck and tires, notwithstanding that less than 3 per cent of all the trucks observed exceeded the maximum weight allowance of the Connecticut law, which is 25,000 pounds. For seven-eighths of the violations of the maximum weight provision and three-quarters of the trucks loaded beyond their rated capacity the regular trucking companies were responsible. The practice was not confined to loads of heavy material such as sand, gravel and brick. Apples, beer, butter, eggs, drugs, fish, furniture, meat, vegetables and, in fact, nearly every commodity transported was represented in the records of overloads.

The significance of this observed fact will depend upon the relation which is found to exist between road strength, wheel load and tire width. Such investigations are in progress by the Bureau of Public Roads at the Arlington, Va., Experimental Farm. It goes without saying that roads must be designed to carry some given maximum load, and it is already clear that the imposition of a greater load after the road is constructed overtaxes the road. Repeated applications of such excessive loads or even occasional applications of greatly excessive loads are likely to damage the road far beyond the small gain in the operating cost which results from carrying the additional load, if, in truth, there is any gain. Certainly, therefore, those trucks which were found to be carrying total loads in excess of the legal maximum of 25,000 pounds were guilty of an offense against the road cal-

culated to cause loss to the community which was paying for the road and the transportation.

Overloading Is Common

THE effect of the overloading of smaller trucks when the greatest wheel load does not exceed the maximum used in design has not yet been determined beyond doubt. State laws prescribe a limit, generally 800 pounds per inch of tire width, which is intended to prevent excessive concentration of load on the road, and the trucks which were found in Connecticut to be loaded beyond the rated capacity of the trucks and tires were violating the State law. Investigations made thus far give some reason for the belief that such overloading, so long as the given maximum wheel load is not exceeded, may not be followed by serious consequences, but the point is not at all clear. It is possible that the effect upon some types of surface may be more serious than upon others. This much is certain, that the operators of those trucks were guilty of a practice which, for all they knew, might seriously damage the road, and which in the long run would certainly reduce the life of their trucks, and yet for the sake of small temporary gain they risked the consequences.

So long as there is such disregard of economic law, highway transport will never become the efficient link in our transportation service that we should hope to make of it. Again comes up the problem of individualism which the railroads do not have to face and another indication of the need for research looking to the establishment of uniform, just and reasonable traffic regulations and means for their enforcement.

In view of the fact that truck and railroad transportation are more seriously in conflict in New England than in other sections, certain comparisons developed by the Connecticut data are interesting and important. Classifying the commodities hauled by the trucks and comparing them with similar classifications of railroad tonnage results as follows:

Comparisons of Commodities Hauled by Motor Trucks and Railroads in New England

Class of Commodity	Truck	Hauled by N. Y., N. H. & H. Ry. (1918)	B. & M. Ry. (1920)
Products of agriculture	14.3	9.4	11.8
Products of animals	11.2	3.3	3.2
Products of mines	0.5	42.5	36.8
Products of forests	1.5	6.5	13.2
Manufactures and miscellaneous	72.5	38.3	35.0

Remember that the high-pay tonnage lies in the group of manufactured and miscellaneous commodities and that products of the mines and forests are low-class freight, and you will see from the table what the truck is doing to the railroads. It is invading their most lucrative field and taking a part of their business in that field, but it is not taking over any of the burden of carrying the bulky, low-class freight.

Now consider the further fact revealed by the Connecticut census: That the trucks are carrying some of those manufactured commodities for distances which exceed what is ordinarily understood as short-haul distances of more than 100 miles and as high as 150 miles. Consider further that the two competing railroad systems are short-haul systems, as railroad hauls are rated, and you will appreciate the situation in which the railroads find themselves.

The transportation conditions in New England are almost unparalleled in other sections. Perhaps the railroads have not adjusted their service as well as possible to the peculiar conditions. In some respects they certainly have not. The fact remains that, so far as we can see now, New England could not get along without its railroads, and their position must not be rendered impossible by ruinous motor truck competition. Bearing in mind that what we are after is not the improvement of highway transportation only, but of all transportation, it will be clear that there is need for research to define the proper fields of the two transportation systems in this area especially. A way must be found to make them aid each other and to put an end to expensive conflict.

An investigation similar to the Connecticut study has been made by the Massachusetts highway commission. The results have not been published, but it is understood that in many respects they verify the Connecticut findings and that they point toward the same general conclusions.

In Tennessee another survey has been under way which goes over much of the ground that has been covered by the former censuses and includes some important features that have not been accounted for in the others. This survey, the complete results of which have not yet been published, has been conducted by Prof. N. W. Dougherty, of the University of Tennessee, who has been appointed also a special assistant of the Bureau of Public Roads. The work has been done with the cooperation of the university, the State department of highways and the Federal Bureau.

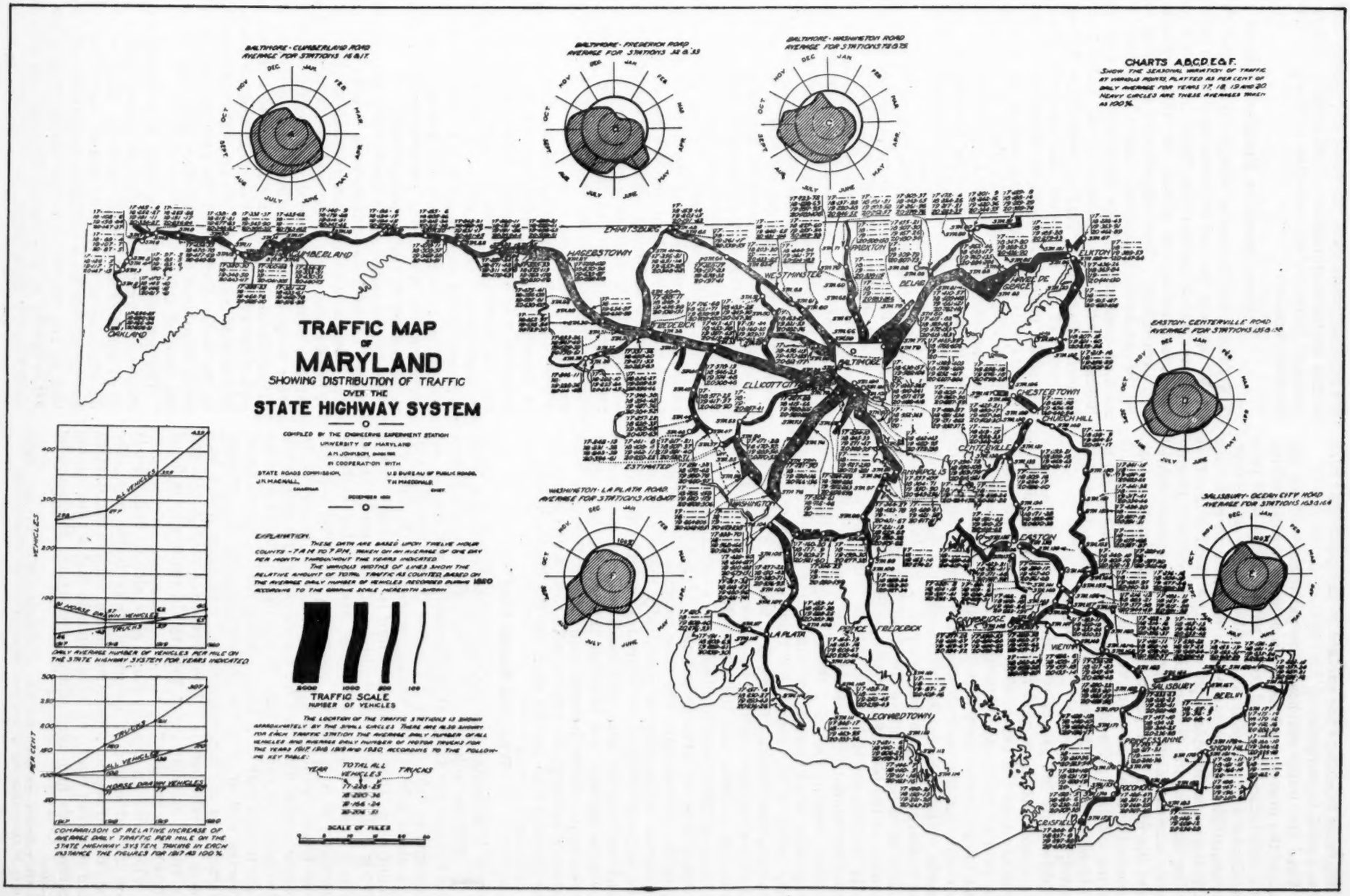
It has been the principal purpose of this investigation to determine the service value of the roads of several counties, of which Davidson County, with Nashville as a center, has received first consideration. The other counties included were Williamson, Maury, Cumberland and Knox in the order of mention.

Reviewing, briefly, the method adopted: The first step was to study the existing condition of the roads, their age and cost of construction, the existing grades, widths, drainage and climatic conditions and other factors which affect the use of the roads and their value as arteries of transportation. The next step was to review the maintenance methods adopted with respect to cost and adequacy.

Unit Transportation Costs

TYPE of surface, character of subgrade, grades, widths, etc., plus character and completeness of maintenance indicate service potentiality. Costs of construction plus maintenance constitute the roadway charges to be considered with the operating costs of the traffic in arriving at a combined roadway and operating cost which will be a measure of the efficiency of the transportation. The investigation proceeded to a count of the traffic by roads, classifying the vehicles as automobiles, motor trucks (roughly classified by capacity) and horse-drawn vehicles. So far in his investigation Prof. Dougherty found it possible to obtain representative, if not complete, data. With these data and the operating costs of vehicles related to the roads over which they are operated, he would be in a position to show with a fair degree of approximation what are the total and unit costs of transportation over the various roads. But it is right here that he has struck a snag, which has prevented him from carrying his analysis to its logical conclusion. He has not been able to secure accurate costs of operation—even average costs—and he needs something more than average costs. He needs detailed costs—detailed with respect to the highway surfaces and grades to which they relate. Such information is vital to a proper selection of surface types. Knowledge of traffic volume related to annual road charges will show from the viewpoint of the road, for example, at what stage of traffic development it

Results of a Traffic Census


BALTIMORE - CUMBERLAND ROAD
AVERAGE FOR STATIONS 16 & 17
BALTIMORE - FREDERICK ROAD
AVERAGE FOR STATIONS 32 & 33
BALTIMORE - WASHINGTON ROAD
AVERAGE FOR STATIONS 28 & 29
CHARTS A, B, C, D, E & F.
SHOW THE SEASONAL VARIATION OF TRAFFIC AT VARIABLE POINTS PLOTTED AS PER CENT OF DAILY AVERAGE FOR YEARS 17, 18, 19 AND 20. HEAVY CIRCLES ARE THESE AVERAGES TAKEN AS 100%.
TRAFFIC MAP
OF
MARYLAND
SHOWING DISTRIBUTION OF TRAFFIC
OVER THE
STATE HIGHWAY SYSTEM
COMPILED BY THE ENGINEERING EXPERIMENT STATION
UNIVERSITY OF MARYLAND
A.N. JOHNSON, DIRECTOR
IN COOPERATION WITH
STATE ROADS COMMISSION, J.N. MACHALL, CHAIRMAN
U.S. BUREAU OF PUBLIC ROADS, T.H. MACDONALD, CHIEF
DECEMBER 1920
EASTON - CENTERVILLE ROAD
AVERAGE FOR STATIONS 15 & 16
WASHINGTON - LA PLATA ROAD
AVERAGE FOR STATIONS 10 & 11
SALISBURY - OCEAN CITY ROAD
AVERAGE FOR STATIONS 13, 13 & 14
EXPLANATION
THESE DATA ARE BASED UPON TWELVE HOUR COUNTS - 7 A.M. TO 7 P.M., TAKEN ON AN AVERAGE OF ONE DAY PER MONTH THROUGHOUT THE YEARS INDICATED.
THE VARIOUS WIDTHS OF LINES SHOW THE RELATIVE AMOUNT OF TOTAL TRAFFIC AS COUNTED, BASED ON THE AVERAGE DAILY NUMBER OF VEHICLES RECORDED DURING 1920 ACCORDING TO THE GRAPHIC SCALE HEREWITH SHOWN.
TRAFFIC SCALE
NUMBER OF VEHICLES
THE LOCATION OF THE TRAFFIC STATIONS IS SHOWN APPROXIMATELY BY THE SMALL CIRCLES. THERE ARE ALSO SHOWN FOR EACH TRAFFIC STATION THE AVERAGE DAILY NUMBER OF ALL VEHICLES AND AVERAGE DAILY NUMBER OF MOTOR TRUCKS FOR THE YEARS 1917, 1918, 1919 AND 1920, ACCORDING TO THE FOLLOWING KEY TABLE:
YEAR TOTAL ALL VEHICLES TRUCKS
17-206-25
18-230-36
19-156-24
20-204-31
SCALE OF MILES
ALL VEHICLES
TRUCKS
HORSE DRAWN VEHICLES
DAILY AVERAGE NUMBER OF VEHICLES PER MILE ON THE STATE HIGHWAY SYSTEM FOR YEARS INDICATED
COMPARISON OF RELATIVE INCREASE OF AVERAGE DAILY TRAFFIC PER MILE ON THE STATE HIGHWAY SYSTEM, TAKING IN EACH INSTANCE THE FIGURES FOR 1917 AS 100%.

is desirable to change the surface of any particular road from gravel to concrete.

When the traffic reaches some particular volume the cost of the gravel road, made up of cost of construction plus maintenance reduced to an annual basis, will pass the similar cost of a concrete road. At that stage, from the standpoint of the road, it is desirable to resurface with the more durable type. But the chances are that before that stage is reached the gravel road will already have become a relatively unprofitable investment viewed from the higher standpoint of total transportation cost, because the owner of every vehicle that passes over it is paying a higher price for his operation than he would be required to pay if the surface were concrete instead of gravel.

Individuals and groups of individuals, which is to say the community, have paid that higher cost of operation from the time the gravel road was built, but so long as the sum of the annual operating cost and the annual cost of the gravel road does not exceed the sum of the two costs for the concrete road the gravel road should remain. The more durable surface should be laid when the balance swings to the other side. It is this point which is not determined by Prof. Dougherty's data, because of the lack of relative operating costs.

He has, nevertheless, been able to bring out some interesting relations, and although his complete report has not yet been published, I think I may take the liberty of quoting briefly by way of illustration from a preliminary draft of the report for Davidson County. "For example, the Harding Pike has a total of 8775 vehicle-miles over a distance of 14.5 miles, giving an average intensity of 605, and the Charlotte Pike has a total volume of 2324 vehicle-miles over a distance of 8.75 miles, giving an average intensity of 255. These two pikes are of practically the same construction, requiring an annual expenditure of practically the same amount. The highway commission estimates that the annual expenditure for the main pike roads will not exceed $750 per mile per year, not counting interest on the original investment. Seven hundred and fifty dollars per mile per year would give a vehicle-mile cost of 0.34 cents for the Harding Pike and 0.8 cents for the Charlotte Pike.

What Do Roads Cost?

"IT is estimated that the district roads will cost about $500 per mile per year. The traffic will vary from a few vehicles per day to about 200 vehicles per day. . . . Twenty-five vehicles per day makes the vehicle-mile cost 6.23 cents (sic) if the annual expenditure is $500. It would seem, therefore, that there is a minimum traffic which will justify an expenditure of $500 per mile per year. If the same relation* be assumed for highway operation as for railway operation, the total cost per vehicle-mile would have to be 31.15 cents to justify an expenditure of 6.23 cents for maintenance and structures. Ordinarily 31 cents would be counted high for average vehicle-mile cost on a hard surface road. Assuming an average cost of 15 cents per vehicle-mile, the (proportionate cost of) maintenance and structures would be 3 cents per vehicle-mile. Three cents per vehicle-mile and an annual expenditure of $500 would require a traffic of 50 vehicles per day."

The Davidson County study aims also to find a basis for the estimation of future highway traffic using the rate of increase of population, motor vehicle registration and observed traffic as arguments to find a relation between roads and agricultural production; to determine the effect of roads upon the value of property and finally to find by the combination of the several factors a more adequate basis for the selection of roads of the county for improvement.

*In railroad operation the cost of maintenance of way and structures is approximately 20 per cent of the total cost of operation.

Vehicle Operation Relative to Road

WHAT the Tennessee studies have failed to reveal, namely, the cost of vehicle operation relative to the road over which the operation takes place is the subject of two investigations, one in Iowa, the other in Massachusetts and Connecticut. These experiments are being conducted by the committee on economic theory of highway improvement, a committee of the Advisory Board on Highway Research which is a division of the National Research Council. Prof. T. R. Agg of Iowa State College is the chairman of the committee, and the Iowa tests are being made under his personal direction. The Massachusetts tests which are being made at the Massachusetts Institute of Technology under Major Mark Ireland of the Quartermaster Corps, U. S. A., are known as the Quartermaster Research on Tractive Resistance. Correlated tests are being made at Yale University under the direction of Prof. E. H. Lockwood.

The Quartermaster Research aims to discover the total resistance to traction of motor vehicles, including the sum of all resistances within the vehicle itself and the resistance of the road. The concrete road will be used as a basis of comparison and most complete data will be secured for that type. Comparative data will be secured for other types. A measure of the roughness of the road surfaces tested forms a logical part of this research. At Yale, tests are being made to ascertain separately the magnitude of the various internal resistances, such as the inertia and frictional resistances of motor and transmission, and tire resistances. These resistances evaluated, they can be deducted from the total resistance as found by Major Ireland and the remainder will be the road surface resistance which correlated with the type of road and the measured roughness of the particular road section will furnish the means of predicting road surface resistance from the type of the road and the measurable roughness.

Out in Iowa Professor Agg hopes to convert the results of these two investigations into terms of gasoline consumption and hence, finally, into cost of vehicle operation for particular classes of roads of known roughness. By combination of the results of the three experiments it should finally become possible to predict from the type of road and its roughness the average cost of vehicle operation over it which is precisely what has been shown to be lacking in the Tennessee data.

Briefly, Professor Agg's method will be to operate three classes of vehicles—automobiles, trucks and trailers—over selected sections of concrete and bituminous concrete or brick roads. Special devices he has contrived will preserve a continuous record of gasoline consumption at every stage of the operation and a correlated record of the profile of the road showing grades and roughness, together with a record of the speed and air pressure front and back of the machine at each instant during the course of the tests. Samples of the gasoline will be taken and tests made upon them will show their fuel value in British thermal units.

The net result of these tests, it is hoped, will enable Professor Agg to determine the money cost to the traffic of grades and highway surfaces. Such results should be available at a not very distant date. No similar information has been available heretofore with the exception of the results of a few simple tests made several years ago by A. N. Johnson, then serving with the Portland Cement Association.

All the foregoing researches, the primary purpose of which is to provide a basis for determining the service value of roads and the actual cost of highway transportation must necessarily depend upon the various physical researches which are being made to determine the necessary constructural features of the roads and the vehicles to withstand the forces which react against each at the points of contact of wheels and road surface. Obviously changes in vehicle design which alter the concentration of load on the wheels, or the tire medium through which the load is transmitted will affect the construction of the road and the construction of the road will affect its cost. Improvements in vehicle efficiency will affect operating costs, so that it is clear that the economic and the physical researches must go hand in hand. The latter are another story which is told by Professor Hatt elsewhere in this number.

Naturally the design of the vehicle affects the cost and character of the service in many ways entirely aside from the road relation. The substitution of pneumatic for solid tires has its effect not only through its influence in reducing impact troubles of both the road and the vehicle, but directly, in the character of the transport service. Consider, for example, the difference between a motor bus on solid tires and on pneumatic tires. Body sizes, the relation of weight of cargo to volume of cargo, the field of the four-wheel-drive, these and numerous others are matters of vehicle design which directly affect service and which merit and are receiving careful study by many vehicle manufacturers and various users in the course of everyday business.

There remain to be discussed briefly a number of fields of study related to the use and service of vehicles, including the type and capacity of motor trucks for various industries and for short and long hauls, for intercity hauling and city delivery use; including terminal uses of motor trucks in connection with the railroads and the future terminal problems of the motor truck services themselves, if intercity passenger and commodity transportation is to continue to develop. There are problems associated with the use of trailers—when to use them and how best to operate them; what special loading and unloading requirements attach to their use? Is there hope of greater economy in specialized corporate control of highway transport than in the present prevailing practice according to which nearly every man is his own carter? What are the possibilities of co-operative operation? If, as is generally conceded, the highest development of the specialized trucking industry depends upon the adoption and maintenance of regular schedules, equitable classification of commodities and equal rates to all for equal service, how will such schedules be determined and such rates and classifications be established? What are the possibilities of establishing central warehouses by means of which trucks will be assured of return loads? These are some of the service problems; there are many more, and the indications are that they are to receive the study they deserve if the recommendations of Mr. Tom Snyder, secretary of the National Association of Commercial Haulers are widely carried out.

The research in this field has been carried on mainly by the questionnaire method and in connection with the daily business of vehicle manufacturers and motor trucking companies. H. R. Tolley and L. M. Church of the Bureau of Public Roads, as previously mentioned, have developed a great deal of important data with regard to farm uses of motor trucks by the questionnaire method. The reports of their work published as bulletins of the Department of Agriculture cover such matters as the size of trucks used by farmers engaged in truck farming, dairy farming, fruit, crop and general farming and the satisfaction or dissatisfaction of the various owners with the trucks of their choice. They have obtained the opinions of farmers on the question as to whether their trucks are profitable investments; they have compiled information with regard to the length of farm hauls, time saved by the use of trucks, the percentage of return loads, the extent to which the change from wagons to motor trucks has permitted the farmers to reach new and better markets, the number of days use per year, the life and depreciation of the trucks under farming conditions, the cost of repairs, the saving in hired help, the displacement of horses and approximate statements of the cost of operation. Such data have been compiled for the Eastern and Corn Belt sections, and they constitute a valuable contribution to the developing science of highway transport. Other industries should be studied in a similar manner.

"EXECUTIVES of car and truck companies will have to take a more active interest in highway research or they will wake up some morning and find that their sales cannot go on because there aren't proper road facilities for taking care of the manufactured vehicles. We can't go on producing cars without thinking seriously and scientifically about road problems."

This statement was made recently by one of the most prominent executives in the industry. And he was right.

Highway construction, finance and operation are going to be studied in the future more carefully and accurately than in the past.

The highway is a necessary economic unit. It must be made to pay its own way. Public funds will not always bear the burden. Research is essential to the attainment of this end.

As a result of the rapid increase in the traffic on the highways the prevention of accidents has become a matter of the first importance. State highway departments are giving more and more of their attention to this and the associated problem of the guidance of traffic. As yet there is an unfortunate lack of co-operation in the efforts that are being made by the various States. There is a wide variety of caution and directional signs which is in itself a source of confusion and positive danger.

One of the most interesting experiments in the field of accident prevention is that which is being conducted by the State Roads Commission of Maryland. It is not only an interesting experiment, it is also a valuable administrative measure, for its results are being applied directly by the Commission to the elimination of dangerous places on the State highways. By a system of reports the commission receives from its patrolmen an account of every accident which occurs at any point on the State roads immediately after the accident. Each accident is recorded on a map of the State system by the insertion of a pin with a colored head, yellow for a mishap involving no loss of life and red for fatal accidents. Whenever possible the cause of the accident is stated in the reports, and when there is indication that the road is at fault a special inspection is made of the site by an engineer and steps are taken at once to remedy the dangerous condition. The grouping of the pins on the map has brought out very clearly the most dangerous places on the system, and in many cases they are places which had previously been considered entirely safe.

As previously suggested the regulation of traffic is in a far from satisfactory condition, taking the country as a whole. Each of the States has adopted its own regulations without much regard for the regulations of adjoining States with the result that when a motorist passes from one State to another he must learn almost an entirely new code. One of the reasons for this lack of uniformity is the fact that there has been heretofore no very definite groundwork of experimental fact upon which to base the regulatory provisions.

A considerable amount of study has been applied to the problem of bringing the various regulations into uniformity and one of the notable results is the uniform motor vehicle law drafted by the Federal Highway Council. Most of the provisions of this model law appear to be so reasonable as to be worthy of immediate adoption by all States. A few, particularly the limits placed upon weight and speed of vehicles, will probably be affected by physical research now under way, and their adoption should await the conclusions to be drawn from these researches.

Store-Door Delivery

WHAT is popularly known as store-door delivery, by which is meant the plan of direct collection and delivery of freight by the rail carriers has been a subject of much interest in the cities for several years. It is not an untried experiment. In its major features it is really a successful institution of long standing, the Pennsylvania and Baltimore and Ohio railroads having practiced it in Baltimore and Washington for nearly half a century. As a result of decisions in cases before the Interstate Commerce Commission the practice was unwisely abandoned in these cities a year or so before the outbreak of the world war. Since the war it has attracted widespread attention and we are likely to see its adoption generally by all cities before many years have passed. It is almost a panacea for railroad terminal congestion. Such congestion results in large measure from the piling up of less than carload freight in the terminals, due, in the first instance to the delay in delivery which results from the necessity of mailing a notice of receipt to the consignee, and secondly, to the delay of the consignee himself in sending to the terminal for his freight. Under the system of store-door delivery the l. c. l. freight is not permitted to remain in the station but is unloaded directly from the cars into trucks which convey it directly to the consignee, the same trucks returning from their delivery trips with outbound freight for loading upon the cars.

As formerly practiced in Baltimore and Washington motor trucks were not considered to be as successful as the horse-drawn dray for this purpose on account of the numerous and lengthy stops for loading and unloading. This difficulty has been practically overcome by the development of demountable container bodies which can be quickly placed upon the trucks by travelling cranes at the terminals, and the principal obstacle that remains is the matter of unloading. In this respect there are still some problems to be worked out.

After a thorough investigation the principle of store-door delivery has been recommended by the Port of New York Authority for the present relief of congestion in our principal port. The proposal contemplates the use of motor trucks with demountable or container bodies to avoid all unnecessary handling and reduce to a minimum the loading and unloading time of the trucks leaving them free to perform the function for which they were designed—the rapid carrying of freight. For those merchants who do not desire direct delivery or whose business is not of such a character as to permit it the proposal of the Port Authority is to build centralized union freight stations located at such points as to minimize the truck mileage in delivery and collection, these stations to be erected inland from the waterfront in order to reduce the congestion at the piers.

Container Cars

A MODIFICATION of the system of store-door delivery has recently been successfully adopted by the railroads centering in Cincinnati for the transfer of freight between the several roads and between the main stations and substations. The method seems to be ideal for this purpose. Freight can be loaded and unloaded in container bodies by means of cranes and the trucks are practically assured of a full load both ways with negligible delays at the two ends of the trip. The experiment, known as the Cincinnati plan has resulted not only in a saving of time and the elimination of a great deal of rehandling, but has also released a great many freight cars from the interline transfer service for use on the main lines, has reduced the number of standing cars on the yard tracks, thereby improving the track service for carload freight unloading, and has made it possible to accommodate a much greater amount of l. c. l. freight on the available area of loading platform.

German Determinations of Road Adherence Coefficients

PROF. DR. BREDTSCHNEIDER of the Berlin Technical College publishes in the *Verkehrstechnik* the following road adherence constants obtained on the Avus automobile track near Berlin, with different types of tire and under different conditions of road surface. The tests were made on a level stretch with the dynamometer inserted between one car acting as a tractor and another acting as a load, the brakes on the latter being applied. The passenger cars were fitted with pneumatic tires, the left front and right rear wheel tires being of the steel studded anti-skid type, whereas the trucks had the usual solid rubber tires.

The figures show that the steel-studded pneumatic tire has only slightly more adherence than the smooth-tread pneumatic tire on wet wood block and asphalt pavement,

	Coefficients of Adhesion					
	Passenger Vehicles Non-skid			Smooth Tread	Trucks Solid Rubber	
	Condition of Road Surface					
Road Surface	Dry	Wet but Not Muddy	Dry	Wet but Not Muddy	Dry	Wet but Not Muddy
Tarred macadam..	0.50	0.45	0.56	0.50	0.62	0.57
Wood pavement...	0.44	0.34	0.60	0.30	0.62	0.22
Asphalt pavement.	0.39	0.32	0.53	0.27	0.60	0.25

and is inferior to it under other conditions. As the steel-studded tire also has other drawbacks it will be replaced in Germany before long by the rubber non-skid tread tire.

The Motor Bus—Today and Tomorrow

Cost studies help define proper field of bus transportation. Return on investment more important factor than operating cost. Experiments in design are widespread. Greater comfort for passengers sought. Limousine bus makes appearance. Better feeling between bus and railway interests.

By Walter Jackson

JUST enough has been learned as regards design, operating costs and possibilities of use of motor buses to indicate that a broad field of usefulness lies ahead and that further development is certain to take place. Numerous investigations are now being conducted.

A growing tendency toward co-operation between electric railway, railroad and bus interests is evidenced by studies in the commercial phase of motor bus problems. Analysis of bus operating costs under various conditions show that the ultimate field of this type of vehicle will depend upon many factors other than the mere operating cost of the vehicle. The bus often returns greater profit than the electric car, even though its vehicle operating cost is greater.

The general tendency in motor bus design is toward the one-man 25-seat vehicle, but standardization in body design is not likely, nor perhaps desirable, in the near future. Lower bodies and door steps are necessary, while other comforts and conveniences for bus riders are rapidly being developed. Experiments with lighter pressed steel frames are in progress. Six reflector units equipped with 21 cp. Mazda C to give about 6 ft.-candles on the reading plane are recommended for lighting a 20-ft. bus as the result of recent researches along this line. These are the chief features which stand out from a survey of bus research from a construction standpoint.

All the investigations and experiments now under way may properly be regarded as research activities so far as the motor bus is concerned. The comparative newness of the bus as a transportation medium makes it necessary to classify as research many items which would be little more than historical data if related to older units. The cost per passenger-mile of hauling passengers, for instance, has been so thoroughly studied in the railroad field that such data is scarcely in the realm of research at the present time. Yet these same data, gathered and interpreted in relation to motor bus transportation very definitely constitute research material because so little has already been done in this field.

Final results are not yet available from either the construction or operating research already completed or in process, but some very definite trends are already evidenced, as is shown from an examination of the various researches in progress throughout the country. This article contains a summary of those researches and the trends so far developed by them.

The commercial growth of the motor bus will be determined by its ability to provide efficient transportation. Consequently the studies of operating costs, service possibilities and transportation economies are important to bus manufacturers. The co-ordination of bus lines with existing transportation mediums is one of the major problems.

Every bus manufacturer who expressed himself on this subject said that traction men are rapidly losing the idea that there is nothing to the bus. Their inquiries from traction companies had, indeed, greatly increased within even the last twelve months. Those who attended the October, 1921, and February, 1922, sessions of the American Electric Railway Association sensed an appreciable turn for the better within the few months intervening. It is true that the embargo on bus company membership adopted in October was not revoked in February, but there is nothing to prevent a maker of buses from becoming a member and sitting on committees—a rather anomalous situation.

SOME of the motor bus installations made by electric railways within the past year tend to make the anti-bus element look foolish. One company has installed buses on a cross-town line because they are cheaper than rail renewal; a second, to make one good bus route of two bad rail routes; a third, to save the wages of flagmen compelled with car operation; a fourth, to get rid of some jitneys by running buses to a neglected area; a fifth, to protect itself against pirates on a cross-country line, etc. Every day sees some new situation where the bus is not a competitor but a money-saver and even a money-maker for the electric railway. However, it will take years before even the progressive electric railway man forgets the jitney's ravages, not to mention the considerable tribe who are still at gripes with it. Those who insist upon dying with their boots on will find themselves succeeded by bus companies—not individual jitneurs—with a better sense of responsibility to a public which will put up neither with antiquated vehicles nor antiquated management.

The over-enthusiastic bus advocate dislikes to learn how cheaply a truly modern electric railway can be operated. Perhaps it is because of this that we have seen such desperate skimpings in equipment and service to produce operating costs that would look better than the railway's, making no allowance for the burdens that eventually will fall upon a bus corporation as upon a railway corporation. The biggest field of the bus is in creative work. It can do ever so many things that the rail-bound vehicle cannot do at any price within reason. Therefore the bus manufacturer should cease worrying about attaining a seat cost of ½ to ¾ cents a mile.

The transportation man with business sense will not be interested so much in costs as in net revenue. Admit that for a given situation the bus does cost 50 per cent more to run than the car. It is probably possible then to go on to show why the bus will earn more net through higher schedule speed, greater attractiveness to the public, wider usefulness on holidays and at night. Up to the present time also almost all buses have been used in small, widely scattered lots. The cost of operation under such conditions is certainly not comparable to running 50 to 500 street cars from one shop and carhouse. While the operating costs of the big double-deck companies do not come into the reckoning, they are useful as proof of the reliability and flexibility of the motor bus.

MANY thousands of buses will be ordered within the next two or three years. But it is likely that the greater share will go for new business to meet the never-sated transportation appetite of the American people, rather than for supplanting any existing transportation business.

Various researches show that frequently the bus is preferable despite higher expenses. The following specific studies are typical and illustrate the point clearly:

No. 1 may well be taken from abroad because it offers direct proof of how traffic is created and greater net obtained when a superior form of service replaces an inferior.

The Edinburgh municipality took over a cable system which was to be partly electrified and partly bused. In the meantime the motor bus has been installed on quite a number of lines. Thus the Mound Tollcross cable cars, which made the run in twelve minutes, were replaced Oct. 3, 1920, by buses making the run in nine minutes. This gives a fair idea of the difference in the two services.

Although 46-seat double-deck cable cars were succeeded by 30 to 32-seat, single-deck buses, the receipts per mile increased on the Golden Acre-Mound route within six weeks by nearly 17 cents over cable—58 cents instead of 41 cents.

Now comes the point emphasized as most important—the question of net. The average operating cost of the cable system between January 1, 1919, and May 15, 1920, was only 36.8 cents per mile, whereas that of the buses was 40.8 cents per mile; but the balance to net in the case of the cables was only 5.4 cents, whereas in the case of the buses it was 15.6 cents. These comparisons were not substantially different in the summer of 1920. The buses ran over pretty severe grades and cobble-paved and granite-paved streets over almost the entire route.

The accompanying Table 1 is not given as an example of present costs, which are substantially lower in wages, fuel and first costs, but to show the way the accounts are kept.

Table 1—Typical Cost Set-Up of Edinburgh Municipal Bus Operation, Period July 1, 1919, to May 15, 1920

	In Cents per Bus Mile
Traffic Expenses—	
Superintendence	.032
Wages of drivers and conductors	12.874
Wages of inspectors	.124
Wages of other traffic employees	.076
Ticket check	.564
Uniforms (free to men)	.436
Licenses	.564
Cleaning, oiling and lighting	4.006
Miscellaneous	.277
General Expenses	
Salaries of staff	.368
Store expenses	.162
Office expenses	.078
Printing and stationery	.137
Fire insurance	.226
Accident insurance	.958
Employers liability insurance	.228
National health insurance	.066
Rent of garage	.954
Taxes	.200
Miscellaneous	.102
General proportionate expense of management.	.284
Repairs and Maintenance—	
Chassis	2.490
Bodies	1.600
Tires (solid)	.582
Plant, etc.	.284
Power Expenses—	
Gasoline	12.884
Total operating expenses	40.832
Total revenue	55.490
Carried to net revenue account	15.658

No. 2 is also taken from British practice. This case involved the operation of cross-country bus services over large areas under a single management instead of small services run by individuals, as is usual in America at the present time. The Birmingham & Midland Motor Omnibus Company operations are chosen as an example. Last summer this property had 209 buses and 9 char-a-bancs. The focal point of the business is Birmingham, from which there radiate scores of regular bus routes up to distances of 126 miles, aside from any combination that parties chartering buses may desire. Competition of the individual bus man with this efficient organization is quite out of the question. It has twelve inspection and repair garages along its main routes, so that the standard Tilling-Stevens gas-electric equipment can be kept in such fine shape as to average 40,000 miles per breakdown (May, 1921). The total expenses and earnings of this cross-country system with 32-seat buses happened to be remarkably close to that of Edinburgh, although the period taken was a year later. The earnings were practically 55 cents per mile, and the operating expenses about 41 cents per mile.

Although some of the buses had been on the job since 1911, the total maintenance staff numbered 261, or only 1¼ men per bus, despite the large number of garages and the inclusion of a body-building staff. Not more than two spare chassis frames and eighteen engines were on hand for a system operating in much rolling country. In fact, the spare parts reserve did not exceed 12 per cent.

No. 3 takes us to the United States. The San Francisco Municipal Railway as early as 1917 used buses instead of immediate tracking for extension services. It now has nine White chassis and eight bodies. The former three routes have been revised to two of somewhat different layout, another proof of easy adjustment to conditions as revealed by trial.

THE route across Golden Gate Park has a round-trip mileage of 4.16 miles and that along the beach 5.5 miles. The operating expenses have hung quite consistently around 26 cents a mile for these T. D. B. and 20/45 models. While this operation from the ends of trolley lines through thinly peopled areas has always shown a loss in itself, there is no doubt that it has helped to build up traffic on the connecting lines and improved realty values from which the city recoups its bus losses. The cheapest form of electric traction available would have cost far more and would not have been subject to instantaneous re-routing.

Even if the San Francisco style of bus operation does not throw off a direct profit, it is for all that an example of the most promising field for bus use by electric railways. Bus sales from this source should go into the thousands, for there is hardly a community which is not

growing beyond the terminals of its street railways. In the old days the roads in the outer sections were simply dirt highways, but in these times well-paved thoroughfares are already down. This means that the track extension would be in paving at prohibitive expense to the railway. Hence there is no way out but gas or trackless bus, with the gas bus winning out in most situations.

THROUGH services to the heart of the city are bound to evolve from such extensive shuttle services. This service, if handled at special fares with no intermediate pick-ups, will give genuine rapid transit to cities which are not large enough for subway and elevated lines and that means cities below 1,000,000 population. Many bus services of the British Electric Traction Company are conducted successfully on this principle. There are instances of it in this country, but we have started at the back door. Instead of specifically developing such a service from the center of the city outward, our non-stop services are generally given by unco-ordinated buses coming in from small or nearby cities or rural areas. Indeed, the non-stop, no pick-up plan is not so much the deliberate intent of the operator as it is of local ordinances intended to protect the urban transport company. In any event, the non-stop, extra-fare bus to suburban centers will also be responsible for the sale of thousands of buses in the future.

No. 4 may be offered as an example of short-cut advantages offered by the bus in cross-country service. The Connecticut Valley Street Railway has long had a trolley line between Greenfield and Turner's Falls, Mass., but the distance via the existing roundabout route was 4.8 miles, whereas rubber-tired vehicles could make the run via a short cut of only 3.14 miles. To protect its investment against jitneys and give the public more service, the company started bus operation in November, 1919, making the run in 15 minutes as against 20 minutes by trolley. Since March 15, 1920, also the company has been getting a somewhat higher fare (minimum of 10 cents for two zones and 15 cents for three) for the superior article. It did not simply superimpose the bus service on the trolley service, but cut enough of the trolley mileage to insure a profit. Co-ordination is obtained by having the trolley leave on the half-hour and the bus on the hour. The car schedule speed is 9.6 m.p.h. and that of the bus 12.5 m.p.h.

In this case also experience showed what parts of the route did not pay. These were abandoned later. The equipment in this installation comprises three 1919 Cadillac chassis, model 57-B, especially lengthened to carry a 19-seat body. A report for the year ended Dec. 31, 1920, reproduced as Table II, shows an operating expense of 33.67 cents per mile and a total overall expense of 35.38 cents per mile against revenues of 28.23 cents per mile. It has been stated, however, that reduction in trolley service offsets these losses. In jitney days the company lost one-third of its revenues to these interlopers, whereas now it is cock of the walk.

The motor bus was one thing ten years ago; it was something else a year or two ago and it will be something still different to-morrow. In what respects is it improving and in what respects can it be improved? This was one question that the editors of AUTOMOTIVE INDUSTRIES wanted answered in this "Research Number." The writer felt that the question was too big to be answered by any one person, so in setting forth the following statements on tendencies in the art of motor bus and motor coach development he has embodied therein the summarized experience of many makers of automotive passenger equipment.

It is easier to talk about body than chassis standardization. From the first, motor buses have been operated by one man, except the double-deck buses in New York, Chicago and Detroit. There are still plenty of 12 to 20-seat bodies mounted on the cheaper priced chassis. These are mostly in the hands of jitney men who do not hesitate to overload them and who otherwise operate under conditions that would not be tolerated in the case of a reliable company. The trend of the better class one-man buses is toward a standard seating capacity of 25, with some as high as 29. The seats are arranged according to the most approved street car plan of longitudinal benches at the entrance-exit and transverse seats wherever wheel housings do not interfere.

Table 2—Operating and Overall Charges, Connecticut Valley Street Railway, Year Ended December 31, 1920

	In Cents per Bus Mile
Maintenance—	
Inspection	2.48
Repairs to body and chassis	5.91
Tires	2.98
Depreciation	8.36
Transportation and Fuel—	
Platform labor, etc.	6.75
Gasoline	5.23
Oil	.22
General and Miscellaneous—	
Insurance, etc.	1.95
Miscellaneous credits	.21
Total operating expenses	33.67
Taxes	.41
Interest on Investment	1.22
Total cost of service	35.38

In view of the absence on a bus of the electro-pneumatic door and step control now installed on many street cars, and in view of the usually higher step and less spacious entrance-exit facilities, a seating capacity of 25 is about as high as practicable if the bus is used in city service. From observation, a crowded 16 to 20-seat bus will not make a better schedule than a 32-seat one-man safety car because its greater flexibility is offset by its longer passenger-interchange time. On the other hand, the one-man bus has a big advantage in both speed and safety over the roundabout single-track cross-country trolley wherever the highways are well paved and straightaway.

The intense competition in the body-building field, from the humblest local carpenter to the experienced car builders, results in the paradox of high prices to the buyer and little profit to the builder. There is as yet no quantity production of one-man buses that would give a low price to the buyer and a satisfying profit to the builder.

UNDER the circumstances, the standardization of such items as seat dimensions, seat spacing, window spacing and sizes, body width and height are far from realization. It took the electric railway industry nearly thirty years to attain one standard car, namely, the one-man type; and hardly had it proved a success when the old game of variations from standard began again. Yet in the electric railway field there are less than half a dozen car builders and only two manufacturers of propulsion and control equipment. If electric railway experience is to be repeated, the only way to achieve even a partial standard will be for a group of powerful manufacturers to build something in quantity and offer it at a price that cannot be touched by the others.

Wise operators are no longer putting 20 to 25-passenger bodies on 1-ton and 1¼-ton chassis. In terms of chassis, 2½ tons capacity is the size best for say 3750 lb. live load (25 x 150 lb.) and for maximum life of equipment. This size is not too awkward for city streets

and it offers a good capacity for chartered parties. The true field of the smaller size is for hotel and other private service.

Lower Bodies

THE low-hung body is necessary for safety, riding comfort and ease of access. Side sway, tail whip and triple or even double steps are not good selling points for a discriminating public. One builder says: "A single-step body is, in our judgment, imperative. While we have built, and do build, bus bodies with two steps, we would not do it unless we had to." A low center of gravity in itself tends to easier riding, and to some degree this feature is practicable with smaller wheels. One chassis design has brought the floor only 26 in. above street level through the use of radical constructions, such as gooseneck frames. Further stability is obtained by using a wider wheel gage for the rear than for the front: one design uses 66½-in. front and 71-in. back.

Some bus operators and builders have considered the use of sliding rather than folding doors, but street railway experience indicates that a single doorway with collapsing leaf door is most desirable. The door may be so hung on the front jamb as to be practically automatic in closing through its own inertia. After the bus operator has reached driving speed he may reach over and turn the operating crank to the locked position. On approaching a stop, he moves the handle to the unlocked position, whereupon the door opens through its own inertia upon the application of the brakes. Proper handholds and also overhead or underfloor connections will prevent the passenger from closing the door on himself.

In some states a rear emergency door is required. Usually, this door is blocked by the cross-bus rear seat and is therefore of doubtful utility in case of panic.

In general, door and step devices on buses have a long way to travel before they can equal the modern electric car which has the convenient powers of electricity and compressed air at hand for such apparatus. In Great Britain, however, the writer ran across the first bus in which the door opening and closing were interlocked with the operations of the engine, just as in the case of the American safety car. So there is no reason for assuming that inventive ability will not find the way toward a higher plane of safety than is now the case.

The public utility automotive business in this country began with the converted second-hand passenger touring car in the East and with the body-carrying freight chassis in the West. Only now are East and West beginning to meet. People who have had no transit facilities at all may be willing to put up with makeshifts for a time, but with what success can uncomfortable accomodations be offered to communities that have had rattan, leather and plush-seated cars for decades and have more lately tested the still greater ease of the deep-cushioned well-sprung automobile?

The best makers in the motor-truck field have seriously turned their attention to a genuine passenger chassis. They are realizing that longer wheelbase and longer and more flexible springs than those suitable for a freight truck are a necessity. There are differences in opinion, however, as to the distribution of the pay load. One manufacturer believes that the accepted commercial practice of carrying 80 to 90 per cent of this load on the rear axle should be used on motor-buses, whereas another maker has cut this to 65 per cent and still another to 55 per cent.

One could write a book on the subject of springs alone. There was the courageous passenger car builder who said in plain print that he would not put his name on any bus body to be mounted on a freight chassis unless his ideas as to suspension were met—an attitude not of truculence, but of sound sense and long-headed honesty. The chassis builders have learned that while hundreds of such "freight-buses" are in use, their operators change springs frequently in addition to trying a variety of shock absorbers, snubbers, pneumatic tires, cushion wheels and cushion tires, etc. All these latter auxiliary devices are helpful. But the fundamental problem lies in eliminating the short, choppy spring with its rapid period of vibration. The 20-passenger bus of one manufacturer who is building a vehicle for human beings has such long alloy-steel springs as 42-in. front and 54-in. rear. Another maker is using chrome vanadium springs of special design to meet varying loads with comfort to the passenger.

A third design, which has attracted much favorable attention, combines long (3½ in. x 62 in.) flat rear springs with rubber shock insulators at the ends. These springs are dead flat under load, perched on top of the axle, with the frame swung between them at a height of about 30 in. when 34-in. cushion or caterpillar tires are used. The advantage of a low frame is preserved by placing the body floor on the frame channels without sills or bolsters.

The rubber shock insulators between the spring ends and the frame are intended to provide a vibration-damping cushion between the axles and the frame equal to pneumatic tires. The elimination of spring shackles and bushings by simple blocks good for a year's running (say 35,000 miles) are auxiliary advantages from the upkeep standpoint. The writer has ridden on this and other types of improved suspension. He believes that if they can be made as pleasant riding at the rear as in the rest of the vehicle, the problem of suitable suspension is a good way toward solution.

Improvements in wheelbase, lower body and in suspension should not be offset by hard seating, cramped seat aisle and low roof clearances. If there is anything that the street car rider despises it is the longitudinal seat upon which comfortable riding is almost impossible. The electric railway operator's excuse was: "We need more standing room," a sentiment that is dying out with the coming of the automobile and motor-bus. The bus maker should study the seating standards of electric railways and strive to improve upon them. A seat back of 18 in., a cross-seat (for two passengers) of 33 in., seat centering of 27½ in. for ample knee room and a clear aisle of 16½ in. to 17 in. are the standards of one wise maker.

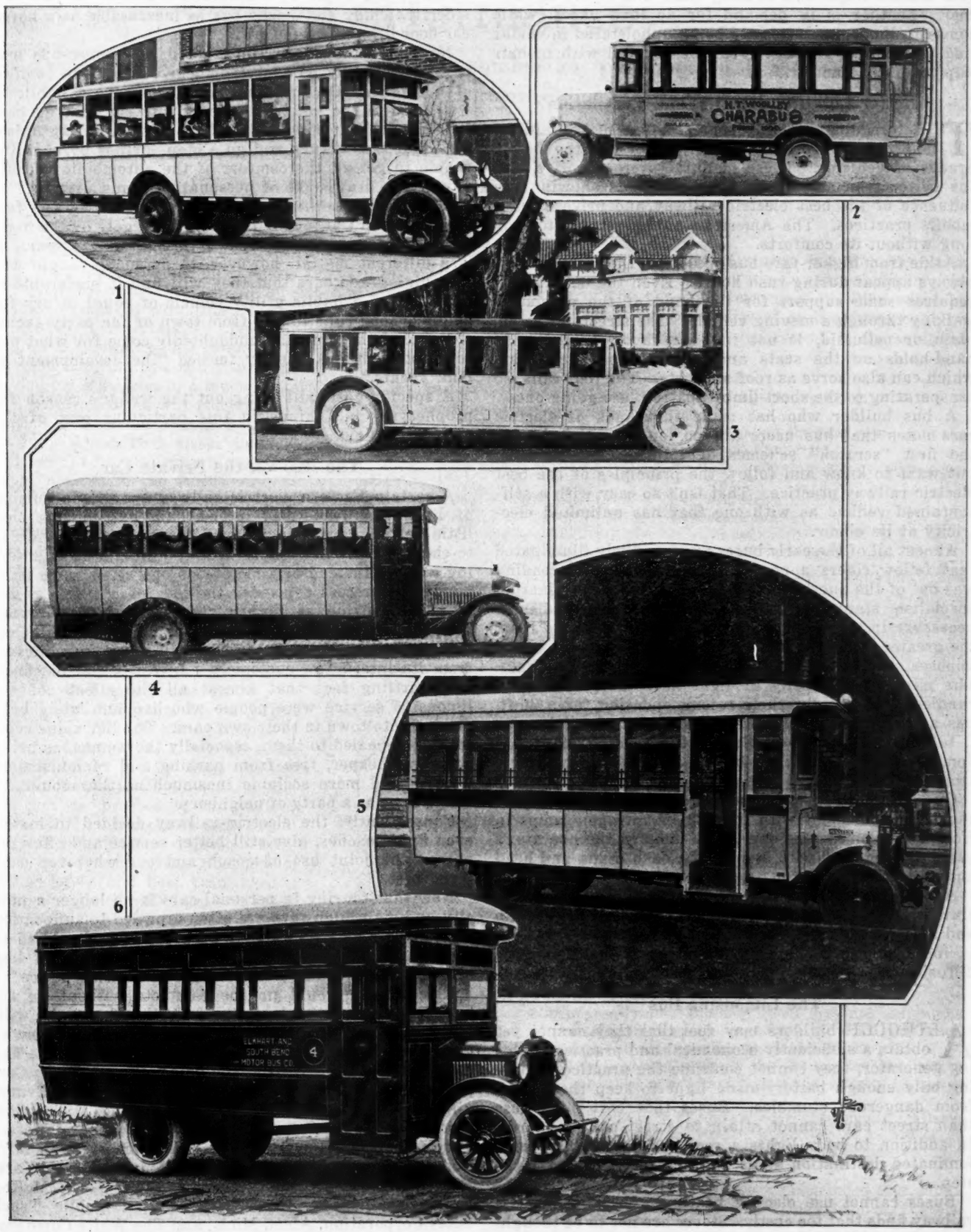
Riding Comfort Improved

SOME electric railways may cling, if they will, to the slat seat for long rides, but the progressive bus operator will not forget that there are some 10,000,000 automobiles in the United States to accustom the Americans to something better. One large builder summarizes his experience as follows:

"The trend is toward lighter, pressed-steel frames and decidedly backward tilt to the seats. The mistake has frequently been made of securing this slope by building up the cushion in front and tapering it down thin in back. This is bad because the cushion is too thin at the back where most of the weight is carried and because the seat back is not sufficiently slanted in these cases. On the other hand, very deep cushions are not desirable on account of excessive bounce, and, the springs for the same reason should be slightly stiffer than in touring car cushions. Where the buyer is willing to pay the price, compound cushions are a great advantage.

"As between rattan, leather and plush seating, rattan

The Modern Motor Bus



1—Garford. 2—Woolley Charabus (British). 3—Fageol. 4—White. 5—Masters. 6—Duplex

seems to have the preference for regular public bus service. Leather and plush are not easily cleaned and do not wear so well. Rattan—the street car favorite—is easily cleaned and is cooler in summer. Plush is universally condemned, though easiest on clothing, because it is almost impossible to keep clean and is hot in summer. Leather is in demand for de luxe buses, while long-run limousine buses are being upholstered in velour and whipcord. The latter can be covered with mohair slip covers in summer."

Better Lighting, Heating and Ventilation

THE foregoing not only expresses one maker's ideas, but those of practically all makers of the better grades of vehicles. These manufacturers report a call for better trim and finish, these demands showing the influence of the best electric railway and private automobile practices. The American public refuses to stay long without its comforts.

Aside from higher-fare bus operation, the standee must always appear during rush hours. Even the de luxe bus requires some support for the hand of the passenger walking through a moving vehicle. The street car strap, plain or celluloid, is not in such favor, however, as hand-holds on the seats and vertical enameled posts which can also serve as roof supports. The roof rails, so exasperating to the short-limbed patron, are going out.

A bus builder who has made thousands of electric cars notes that bus users are no longer satisfied with the first "scratch" schemes of lighting and heating, but want to know and follow the principles of the best electric railway practice. That isn't so easy with a self-contained vehicle as with one that has unlimited electricity at its elbow.

Almost all of the early buses were so dimly illuminated that fellow riders appeared in silhouette, and reading was out of the question. A recent study by illuminating specialists states that an intensity of 6 ft.-candles is necessary in a bus if passengers are to be able to read, the greater vibration of a bus causing eye strain, which imposes a higher intensity of light than in street cars. The minimum intensity of light acceptable is 1.5 ft.-candles. Specifically, their recommendation for a 20-ft. bus are six reflector units equipped with 21-cp. Mazdas C to give about 6 ft.-candles on the reading plane. If dome units are used in a bus of like size, eight 32 cp. lamps are suggested.

One builder (of a 23-passenger bus) provides the passenger compartment with four 32-cp. nitrogen lamps in Holophane domes plus one 32-cp. lamp in the operator's vestibule, together with step lights, dash lights and head and tail-lights.

Another builder has given up dome lights in favor of six special fixtures, each made up of a Holophane bulb and 21 cp. miniature Mazda lamp. The use of reflectors is increasing because they reduce glare and promote diffusion.

The Limousine Bus

ALTHOUGH builders may feel that they cannot yet obtain a sufficiently economical and practical lighting generator, they cannot continue the practice of having only enough battery-made light to keep the patron from dangerous stumbles. Buses that cost much less than street cars cannot attain to street car standards. In addition to body lights a real bus also will have illuminated destination signs and a safety lamp over the step.

Buses cannot use electric heating. Even an electric railway finds that too costly. Stoves are not to be thought of, but hot-water heating is a possibility. All that is available now is the direct use of the exhaust. Good results should be possible with this in a well-built bus. It would be unfair to judge exhaust heating by its alleged application in rattle-trap jitneys. As a number of companies are now making bus heaters and ventilators, which items should be considered together, we can consider the chilly and smelly bus as inexcusable as a horse-car floor littered with straw.

No matter how well constructed the motor bus may be, it can hardly be expected to give limousine comfort at bus fares. On the other hand, we have a public so well used to the luxury of the private car that we cannot lure them to long-haul rides on the highway unless we equal that luxury and go a step further by enabling people to get all the comfort of the automobile without any of the drawbacks of personal care and driving.

We are all familiar with the development of the fast road coach in California, encouraged largely by the high-grade tourist business available throughout the year. It is a different matter, however, to persuade people who own high-grade cars that they will find it preferable to make use of a public utility vehicle of equal luxury for neighborhood runs to and from town or for party excursions. Yet the time has undoubtedly come for what one correspondent has happily termed "the development of land yachts."

A specific case will bring out the writer's reason for prophesying big things in this particular part of the automotive field.

The Bus vs. the Private Car

A certain Eastern electric railway operates a number of lines usually termed inter-urban, but in this case little better than a single-track cross-country route due to the time lost in passing over the streets of intervening towns. Instead of a motor-bus operation, some independent operators conceived the idea of running an enlarged limousine at higher speed and higher prices. They built up a prosperous business. At first the electric railway thought that this traffic had been drawn from its interurban customers. Investigation disclosed the startling fact that almost all the clients of the limousine service were people who had but lately been driving into town in their own cars. The limousine service had appealed to them, especially the women, as being actually cheaper, free from parking and replenishment worries and more sociable inasmuch as they could arrange to go as a party of neighbors.

Consequently, the electric railway decided to install even finer coaches, give still better service and offer the patron the joint use of coach and car wherever each fitted best.

Now that touring in personal cars is no longer a novelty and main highways are often crowded to suffocation with private cars only partly occupied why should there not be a big field for vehicles of equal luxury, of less expense and with more efficient use of highway space?

This article would not be complete without an acknowledgment of thanks to the following firms who willingly set forth their experience to make this review of greater value than it could have been otherwise: The J. G. Brill Company, Philadelphia; Brown Body Corporation, Cleveland, Ohio; Bus Body Corporation, Evansville, Ind.; Duplex Truck Company, Lansing, Mich.; Garford Motor Truck Company, Lima, Ohio; General Motors Truck Company, Pontiac, Mich.; the James Holan Mfg. Company, Cleveland, Ohio; Hoover Body Company, York, Pa.; International Motor Company, New York; McKay Carriage Company, Grove City, Pa.; Republic Truck Sales Corporation, Alma, Mich., and The White Company, Cleveland, Ohio.

Combustion Research—An Aid to Better Performance

Detonation is the most important combustion phenomenon because of its marked effect upon engine performance, but it is not yet thoroughly understood. Factors affecting it are receiving much study. Flame propagation and related subjects are examined by various investigators.

By Herbert Chase

"IT has been proved that the tendency of a fuel to detonate is the one outstanding factor in determining its value for use in an internal combustion engine. Compared with this all other considerations are of secondary importance." This conclusion, reached by Ricardo as a result of his extensive research work for the Asiatic Petroleum Co., had been reached by C. F. Kettering and his associates at a much earlier date. It is significant, however, to have it confirmed by independent investigation, for its meaning is not even yet fully appreciated either by fuel producers and users or by the designers of apparatus, the functioning of which is greatly affected by this phenomenon.

Cylinder pressures approximating 1500 lb. per square inch have been found to result from detonation, even with moderate compression pressures. These peak pressures are thus three to four times the maximum resulting from "normal" combustion, and consequently have an important effect upon design as well as performance.

We know detonation by its effect, and several factors which control it are also known. A study of flame propagation is giving some further light on the subject, and work in this direction is proceeding in various quarters. In other places tests are in progress on explosion of gaseous mixtures and accompanying phenomena, cooling losses and heat transmission through walls of cylinders, and other factors relating to the process of combustion.

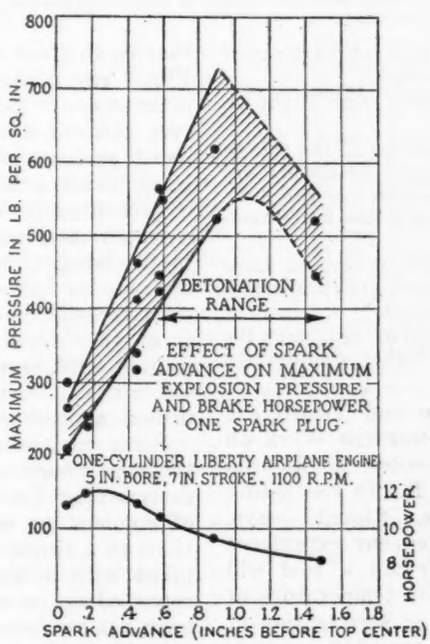


Fig. 2—Curves showing the relation between the spark timing, the maximum pressures reached in the cylinder and the power developed

We have yet to see a satisfactory definition of the term detonation as it is applied to the phenomenon otherwise known as fuel knock, pinking or pinging. We know, or think we know, a lot about this important phenomenon, but it appears to be true that its exact nature is not known. One of the best discussions of the subject is contained in an appendix to the paper on Elements of Automobile Fuel Economy, by W. S. James. The appendix was written by H. C. Dickinson, now manager of the Research Department of the Society of Automotive Engineers, and appears in the journal of the society for June, 1921.

Dickinson says that "the term detonation implies that something occurs in the cylinder which corresponds to the detonation of a high explosive. Such conditions are easily produced in explosive gas mixtures, but there is scant proof that the same thing occurs in an engine cylinder. In fact, some of the experimenters most familiar with the phenomena doubt the possibility of such occurrence.

"Fuel knock, as ordinarily understood, is characterized by the following phenomena:

1—Sharp metallic noise.
2—Bright yellow flame within the cylinder.
3—Decrease in power.
4—Increase in the heat rejected to the jacket water.
5—High instantaneous cylinder pressure.
6—Destructive mechanical effects.
7—Occurrence of smoke in the exhaust.
8—Preignition in most cases.

"Observations show that the occurrence and intensity of the knock are intimately related to the following factors: (1) Chemical composition of the fuel; (2) ignition timing; (3) compression pressures; (4) mixture ratio; (5) position and number of spark plugs; (6) shape of cylinder and piston head; (7) temperature of the charge; (8) cylinder temperatures."

Dickinson discusses the various theories advanced to explain the character of the knock phenomenon and cites experiments which show that:

1—The excess heating during knock is not localized.
2—Pressures in excess of 1300 lbs. per sq. in. were recorded in an engine with 5 to 1 compression ratio using kerosene fuel.
3—The cylinder head is distorted (in the case of a Liberty airplane engine) with sufficient velocity to cause the emission of sound.
4—Apparently fuel knock of itself does not reduce the power but rather the conditions at which the knock occurs are not those for maximum power.
5—There is strong evidence that no marked localization of pressure occurs which depends directly on spark plug location.
6—For the Liberty engine cylinder, the combustion flame must traverse the explosive mixture at a rate of at least 4500 ft. per second to produce the observed rise of pressure.

Dickinson says further, "It may be concluded that whatever the phenomenon of fuel knock may involve, the observed facts are in reasonably close agreement with the

theory that high pressures and attendant phenomena are the result of an abnormal type of combustion.

Ricardo states that the phenomenon of detonation appears to be the setting-up in the cylinder of an explosion wave that strikes the wall of the cylinder with a hammer-like blow.

Ricardo at one time believed that turbulence had an important influence upon the tendency to detonate, but has since learned, as a result of further research work, that he was mistaken in this belief. It was supposed, until recently, that detonation is dependent upon the temperature of compression. Ricardo, Sparrow and others have recently shown that detonation has little connection with the temperature of compression, but is closely dependent upon compression pressure.

Tizard, who has collaborated with Ricardo in his work, has reached the following significant conclusions regarding the detonation phenomenon:

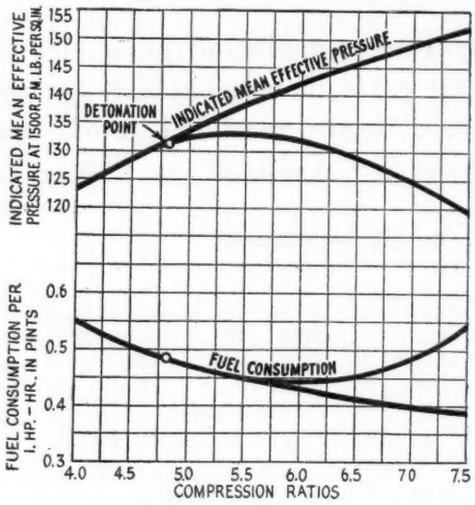
1—It depends primarily upon the rate of burning of that portion of the charge first ignited.
2—The rate of burning increases rapidly with slight increase of flame temperature.
3—The rate of burning of the first portion of the charge depends, so far as practical engine conditions are concerned, upon neither the temperature nor the pressure of compression, but rather upon the flame temperature.
4—For any given mixture strength the maximum flame temperature depends primarily upon the proportion of diluent or exhaust products present.
5—If the flame temperature be reduced by weakening the mixture strength a very much higher compression could be used.

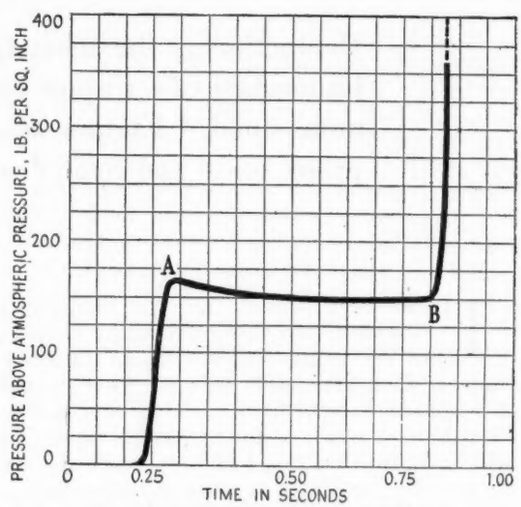
The foregoing statements of Ricardo and Tizard are taken from a paper entitled "Recent Research Work on the Internal Combustion Engine," presented by Ricardo at the last annual meeting of the S. A. E. In concluding his statements regarding detonation, Ricardo says, "Broadly speaking, it would appear from our experience that two factors determine whether or not a fuel will detonate. These are (a) the self-ignition temperature of the fuel-air mixture, and (b) the rate of acceleration of burning as the ignition temperature is exceeded.

"As a broad generalization, our experiments confirmed that, as regards groups, the paraffins are the worst offenders from the viewpoint of detonation, the naphthenes are better, the olefins better still, the aromatics next and the alcohols the best of all."

Effects of Diluents Upon Detonation

It has generally been believed that, in the conventional type of engine, the exhaust products remaining in the clearance space at the end of the exhaust stroke are a necessary evil. It was supposed that if these products could be replaced by air a much improved performance would result. Tests made by Ricardo indicate that quite the reverse is true. It was found that when residual exhaust products had been cleared away by scavenging with air, detonation became severe at once even with very low compression pressures. When additional exhaust products were added by way of the carbureter it was found that the compression could be raised to almost any degree, depending upon the quantity of exhaust gas admitted. "Other tests using nitrogen, steam and carbon dioxide gave similar results. The effectiveness of such inert gases appears to be closely proportional to their specific heats;





(Left) Fig. 1—Indicated mean effective pressure and fuel-consumption curves obtained by adding varying quantities of additional exhaust-products to the charge. (Right) Fig. 3—Curve showing rate of pressure variation following ignition at A

that is, to their direct influence upon flame temperature." Fig. 1 shows the variation in compression ratios permissible when, to gasoline detonating normally at a compression ratio of 4.85 to 1, varying quantities additional exhaust products were added and the compression adjusted in each case until detonation just became apparent.

According to Woodbury, Lewis and Canby,* "there is a certain necessary distance of flame travel from ignition to the point at which detonation is set up, and that the distance is increased by the pressure of diluent gases, even excess oxygen. In the engine the explosion chamber is of very small dimensions and the atmosphere is air diluted with from 10 to 25 per cent of the products of combustion. The possibility of detonation under such conditions appears exceedingly remote."

Some work is in process at Ohio State University, under the supervision of Prof. C. A. Norman, with a view to determining the temperatures reached and the rapidity of combustion under knocking and non-knocking conditions in a single-cylinder engine. Indicator diagrams are taken with a Midgley indicator and these diagrams are replotted on an entropy chart. The results of this work have not yet been published.

S. W. Sparrow, who has been in immediate charge of investigations relating to detonation at the Bureau of Standards, has given considerable study to the cause of this phenomenon. Some conclusions which he has reached in this regard are given in a paper entitled "Detonation—A Consideration of Its Causes," published in these columns on May 4, 1922. For full particulars in this connection the reader should refer to the paper in question. It is interesting to note, however, that the degree of spark advance has a marked effect upon detonation. An engine which is detonating violently with a given spark advance ceases to detonate if the spark is either advanced or retarded a sufficient amount. This is made clear by reference to the diagram in Fig. 2, which is the result of work done by Sparrow.

Ricardo states that the spark plugs should be as near

*See paper entitled The Nature of Flame Movement in a Closed Cylinder, *S. A. E. Journal*, March, 1921.

as possible to the center of the combustion space in order to reduce as far as possible the distance the flame has to travel. If the gases must be ignited from one side of the combustion chamber, he says, the plug should be placed on the hottest side, or the side that is nearest the exhaust valve.

Detonation appears always to be accompanied by a high rate of combustion if, indeed, it is not the direct result of this rate. The velocity of the flame which accompanies combustion is known to accelerate rapidly during the early stages of combustion and finally to reach a very rapid but constant velocity, known as the detonation velocity. Ricardo reached the conclusion that a low rate of combustion is advantageous and that "detonation is less the lower the rate of burning of the fuel." "No fuel has yet been found," he says, "whose rate of burning was too low to permit of maximum efficiency being attained in the highest speed engine yet tested." His work also tended to show that the performance of any combination of hydrocarbons as regards detonation is the mean performance of each of the components.

A very recent report, prepared as a result of research work done on behalf of the (British) Empire Motor Fuels Committee, by W. R. Ormandy, states that there was no evidence that the rate of combustion of 95 per cent alcohol in the engine tested was too slow to obtain the maximum effect—meaning, presumably, maximum power and economy.

Concerning the Efficacy of Dopes

THE General Motors Research Laboratory has for several years been studying the effect of various diluents, often referred to as "dopes," which have a tendency to prevent detonation. Several such substances are understood to have been found, some of them being effective when added to the fuel in proportions 2 per cent or less. It has been the hope of those directly concerned in this work that some substance contained in or easily derivable from crude petroleum would be found which could be readily blended with all gasoline sold by refiners in this country, thus enabling the use of higher compression engines and much greater fuel economy than is now obtained in most automotive vehicles. Kettering and Midgley have discussed the subject in several talks presented before the Society of Automotive Engineers and other organizations. So far as we are aware, no substance commercially available or readily produceable in quantities sufficient to treat any considerable proportion of the fuel produced in this country has yet been found which meets the required conditions.

Ricardo says, summarizing the result of his work, that "no increase in power or efficiency has been found or need be expected from the use of 'dopes,'" a large number of which he tested, but he fails to define the term "dope." If any of the fuels he tested are to be regarded as dopes, it can be assumed by inference from his reports that they are effective only in proportion to their quantity and non-detonating value.

That the tendency of the fuel to detonate is of importance to the refiner as well as to the user of fuels is indicated by the fact that fuels with a less tendency to detonate have been successfully marketed in this country as well as abroad in competition with gasoline at a lower price. In other words, the difference is sufficiently great to be easily distinguished and appreciated by an intelligent user. As a direct result of Ricardo's work, the Shell Marketing Co. has determined to maintain in its fuel a certain anti-knocking standard. Because of the tendency of the aromatic series to prevent knocking, Ricardo concludes that any specifications for a motor fuel should be so drawn as to encourage the inclusion of as large a proportion of the aromatic series naturally present in the crude petroleum as possible.

Flame Propagation

THE subject of flame propagation may seem at first thought to be one of purely academic interest, but that it is a matter of great importance will become apparent to any engineer who gives it careful study. Much careful research work has already been done in this field, and other important work is continuing. Among those who have done important work in this connection may be mentioned Prof. Harold B. Dixon, H. R. Ricardo, various investigators at the Bureau of Standards* and Woodbury, Lewis and Canby of the E. I. duPont deNemours & Co., who have been co-operating with the General Motors Research Laboratory. Among the conclusions reached by the last-mentioned investigators are the following:

> It has been shown that in the case of acetylene-air mixtures ignited at atmospheric temperature and pressure the maximum volecity of flame movement is obtained with that mixture corresponding closely to the theoretical proportion for the formation of carbon monoxide.
>
> It has been substantiated that first record of pressure development occurs after an appreciable distance of flame travel, and that the instant of maximum pressure development coincides with that of total inflammation of the gas charge.
>
> A theory has been presented that the arrest occurring in mixtures fired without turbulence, and the consequent vibrations noted in the burning gases, are due essentially to the high density developed in the gases ahead of the flame front.
>
> It has been confirmed that turbulence greatly accelerates flame propagation, and it has been shown that turbulence changes the character of the flame travel by the elimination of sudden arrest and vibratory movement.
>
> Within the limits of the experiments carried out it was found that increased temperature and pressure have little effect upon the rate of flame propagation.
>
> The initiation of a detonation has been found possible at atmospheric conditions and in a closed cylinder of 12-in. length only by the use of relatively high concentrations of acetylene and a thorough enrichment of the atmosphere with oxygen.
>
> Preliminary results have been presented which indicate that high temperature inhibits the initiation of the detonation.
>
> It has been shown that autoignition of the high-density

*See AUTOMOTIVE INDUSTRIES for April 7, 1921, p. 754, for particulars as to methods followed in tests relating to flame propagation at the Bureau of Standards.

The Effect of Turbulence

IT appears now to be clearly established that the normal rate of burning of a fuel-air mixture is, at the start, far too slow to be of any value; however, its acceleration after a certain stage is extremely rapid.

It is probably in speeding-up the initial stages of combustion by spreading mechanically the pale and timid flame brought into life by the spark-plug, that turbulence plays its most important part, and this becomes most conspicuous when operating with weak mixtures.

H. R. RICARDO.

Mixture Ratio for Power and Economy

FOR present types of automobile engine the maximum power is obtained with air-fuel ratios of from 11 to 1 to 13 to 1 and the maximum efficiency at ratios in the neighborhood of 16 to 1, if the engine will operate regularly with such mixtures.

Where dilution by the products of combustion necessitates richer mixtures the maximum efficiency is attained with the leanest mixture at which the engine will operate regularly.

S. W. SPARROW.

gases ahead of the flame front occurs over a wide range of mixtures and conditions and that it is especially favored by high temperature and pressure.

A theory has been advanced that autoignition of the high-density gases ahead of the flame front is accountable for the fuel knock.

A record of some of Dixon's works appears in a paper entitled "Researches on Alcohol as a Fuel for Internal Combustion Engines," which was published in AUTOMOTIVE INDUSTRIES for Feb. 3, 1921. This paper is not confined to research on alcohol, but, under the heading "Movements of Flame Through Explosive Mixtures," gives a general treatment of that important subject. We shall not here attempt to summarize researches relating to flame propagation, but will mention certain items which appear of special importance to the automotive industry.

It appears to be practically a universal conclusion of investigators in this field that the ignition of a volume of gas at one point does not result in immediate combustion throughout the whole volume. The flame starts slowly at first, and the evolution of heat may at first be less rapid than its dissipation to the walls of the containing cylinder, with the result that the pressure may actually fall for a brief period while the flame is slowly spreading. A sudden increase in the rapidity of combustion is then noticed and this is accompanied by a sudden rise in pressure, which is readily recorded by an indicator.

Pressure Rise During Combustion

IN Ricardo's research work he built a machine for igniting air-fuel mixtures by adiabatic compression. This consisted of a piston arranged in a cylinder in such a way that the gases were rapidly compressed up to the temperature of ignition. At this point the piston was locked so that combustion proceeded at practically constant volume. The curve of pressure rise in one case is given in Fig. 3. It will be noted that combustion proceeds at almost constant pressure from A to B, but at B a very sudden rise in pressure occurs. This curve was made with a mixture of heptaine and air. It is interesting to note that in the particular case covered by Fig. 3 the combustion at constant pressure continues for a period of over one-half second. The interval of slow burning was found to depend to a considerable degree upon temperature. Raising the temperature even a few degrees would sometimes materially shorten the interval of combustion at constant pressure. Variation in the degree of turbulence also varied the period of burning at constant pressure.

Prof. C. A. Norman is engaged in making some determinations as to the rate of combustion and the temperature attained under knocking and non-knocking conditions. He is also investigating, by the use of indicator cards and the entropy diagram, the rate of combustion in Diesel engines with various types of injection. Reports of recent tests in this connection have not yet been published, but Norman states that he has not yet found a solid injection engine in which the combustion proceeds as rapidly as in engines using injection air. He says, "The temperatures in the solid injection engine do not attain the same peaks as with air injection, but are much more sustained. New systems of solid injection are, however, being constantly developed, and some show a more rapid combustion than others."

The Process of Combustion

THE National Advisory Committee for Aeronautics is having conducted at the Bureau of Standards an investigation, the purpose of which is to secure information regarding the process of combustion of various fuels. Three methods are being followed: (1) An investigation as to the rate of combustion of explosive mixtures of air and fuel in spherical constant pressure bombs (soap bubbles), long tubes or cylinders and constant volume bombs; (2) an investigation of the effect of substituting carbon dioxide and water vapor for nitrogen in the air, on the rates of combustion, in similar apparatus, the work to include investigation of the effect of dissociation of the products of combustion on the rates of combustion; (3) an investigation in similar apparatus of the effect of changes in the initial temperature and pressure of the explosive mixture on the rates of combustion.

Effect of Temperature

SEVERAL hundred observations have been made of flame velocity of mixtures of carbon monoxide and oxygen in ignitable proportions, using the Bunsen-Gouy method at temperatures from + 20 to + 100 deg. Cent. The results show that small changes in initial temperature do not greatly affect the flame velocity. It is planned to extend the temperature range from about — 20 to + 200 deg. Cent., and the pressure range from about three atmospheres to one-third atmosphere. The work will be continued with carbon monoxide because of the simplicity of its reaction and to make possible the interpretation of reactions of more complex substances.

The National Advisory Committee for Aeronautics also has in hand an investigation into the performance of gasoline, alcohol and benzol and mixtures of these fuels in an engine cylinder when various ratios of compression and expansion are used.

Prof. L. A. Leutwiler of the University of Illinois is engaged in making an investigation into the explosion of gaseous mixtures. This investigation includes a study of the phenomenon of the dissociation of gases during explosion and of the combustion of liquid fuels in a closed vessel. The methods being followed and the results obtained have not yet been made public.

Prof. C. E. Lucke of Columbia University has in hand an investigation of the subject of heat transmission through cylinder walls and its relation to air and water cooling. The General Motors Research Corp. is known to be conducting investigations along similar lines, but, as in the case with the work of Professor Lucke, results have not yet been published.

Ricardo states that the unavoidable losses due to dissociation and change of specific heat at high temperatures are substantially the same for all of the fuels which he tested.

America Makes Creditable Showing in Aircraft Research

Airplane speed and reliability increased. Development made in helicopters. Research with variable pitch propellers brings results. Europe leads in landing field development. Handley Page slotted wing important feature of aerodynamic research. Insurance and accident studies in progress.

By Archibald Black

INCREASED activity has been witnessed in aeronautical research and investigation during the past year or two, although military construction was greatly decreased. The United States made a very creditable showing in practically all branches of this work and took the lead in some. Airplane speeds of nearly 200 miles per hour, duration records of over 26 hours and altitudes of over 40,000 feet became facts during the past few months. The much heralded Handley Page wing has been built into some full-sized machines and is credited with a "take-off" run of as little as 30 ft.

Helicopters have been constructed which rose under their own power and remained in the air, under control, for periods of an hour, while flights of almost 22 minutes have been made with motorless gliders. The reliability of aircraft engines (from the viewpoint of mileage) has been increased beyond all comparison with other types of internal combustion engines and superchargers have passed the experimental stage. A recently developed system, the Loth cable, enables the aircraft pilot to determine not only his location, but also his height above the ground without visibility.

Commercial operation of airships has been at a standstill, but commercial aviation has obtained a footing in at least seven countries throughout the world.

IN a field of activity, such as that of aeronautics, which is yet in its embryo stages, it is difficult to differentiate sharply between research, investigation and general development. Broadly speaking, all commercial and some military aircraft activity may, as yet, be classed as research and investigation. Consequently the scope of this résumé includes references to activities which in another field would be classed as general development.

Airplanes

Development and refinement of airplanes has continued steadily and is reflected in the constant pushing up to higher notches of the various records. Speeds of close to 200 miles per hour have been attained both here and in Europe, England and France being slightly in the lead. Some speeds in excess of this have been claimed, but the performances have not been fully authenticated. A duration record of 26 hours, 19½ minutes was recently established in the United States by a German machine with American pilots. Through the use of superchargers the altitude record has been steadily raised until it now stands at 40,800 feet, the record established by an American pilot with American equipment. We may be proud of this achievement.

Work on metal construction has been continued, the United States showing considerable, though belated, activity in this field during the past couple of years. Both steel and duralumin are being used here and abroad. Zeppelin and Dornier in Germany produced some very notable developments in duralumin wings, fuselages and floats. A French firm, Wibault, produced a night bombing machine of very good performance, using duralumin construction in the wings and bringing the wing weight below the weight of wood construction. The construction of duralumin floats, which has been successful in Germany, is now being attempted here. The general lines of development have been in improving streamlining, decreasing the number of struts, the use of thick wing curves and increased use of metal construction. The carrying capacity of commercial airplanes per horsepower has steadily increased, thus decreasing their cost of operation. The latest commercial machines are designed to carry loads up to 4.45 pounds of freight per horsepower, or one passenger for each 45 horsepower, while attaining 105 to 110 miles per hour and 3½ to 4 hours' duration. The importance of this is better appreciated if it is considered that such loads are about **five times** the freight and **five to ten times** the passengers that can be carried by a converted military airplane.

Among the notable developments in and near this class were the DH-34, Bristol ten-seater, Handasyde monoplane, Handley Page 25-passenger, Wibault 2-BN-2, Bleriot-Spad, Dornier-Zeppelin, Fokker and Curtiss single engined "Eagle." As notable developments in speed machines there might be mentioned the Gloucestershire "Camel," Curtiss "Wildcat" and Navy Racer, Nieuport-Delage "Sesquiplane," Hanriot HD-22 and the Savoia, a seaplane for which a speed of 160 miles per hour has been claimed. Among machines of particular interest for other features were the Handley Page slotted wing machines; the Zeppelin-Staaken 1000 horsepower passenger airplane, an internally braced monoplane of duralumin, with four engines mounted in the

Fig. 1—Curtiss CT Torpedoplane

wings; the Dornier "Whale," a nine-passenger, all-metal, monoplane flying boat; the Dornier monoplane, cabin flying boat, which makes use of fins instead of wing floats for balancing on the surface of the water; the GAX triplane, an American machine with armored engines and fuselages; the Curtiss-Navy torpedoplane, an internally braced wood monoplane; the Tampier automobile-airplane, a machine equipped with an auxiliary 10-horsepower engine and which can be operated as an automobile by folding the wings and dropping its automobile running gear.

There might also be mentioned the Marcel Besson quadruplane, a four-plane flying boat with an unusual wing arrangement; the Loening boat, a novel type of flying boat with very good performance, and the dePischoff "Avionette," a small machine which flies with a 20-horsepower engine. The Burnelli "Airliner," while flown many times, has not yet proved its worth, but is of interest on account of the use of a very wide streamlined fuselage housing the two engines and a most commodious cabin. The Caproni 100-passenger triplane, while a failure, is interesting on account of its novel arrangement of three sets of triplane wings set behind each other and on slightly different levels. While the arrangement is inefficient, it is conceivable that some modification may be of value later in solving the problems of construction of very large machines.

The Handley Page torpedo-carrying machine may be rated as one of the most interesting developments of the year past. This is an experimental machine embodying the widely advertised Handley Page slotted wing. It showed in a startling manner what this wing can do in the way of lowering landing speeds.

While the machine is surrounded with considerable secrecy, presumably authentic reports state that it took off in a slight head wind (the velocity not stated) in a distance of about 30 feet and landed vertically in the same wind. The slots were, of course, open during take off and landing. The performance of this machine, assuming the report to be correct, certainly makes the value of the helicopter rather questionable.

Airships

Development in this branch of the aircraft industry has not been very active during the past year. The most notable advance is probably the Goodyear military airship, with its novel propelling mechanism (described elsewhere) and generally clean lines. Preliminary tests showed a high speed of 63 miles per hour, exceptionally good performance for a non-rigid airship. An American non-rigid, inflated with helium, is being experimented with. The U. S. Air Service has developed a portable mooring mast for small airships and the British conducted some experiments on the making of repairs to rigid airships while moored to a mast. These experiments have been very successful to date. In one of the British tests a rigid airship rode out a wind of forty-eight miles per hour. The Bureau of Standards is now conducting tests of wind screens for airship hangars with the object of reducing eddy currents.

Extensive plans for operation, with government support, of the British airships on commercial lines were made and one military rigid was converted to a passenger ship. Difficulty is being experienced in finding capital willing to assume the risk, but the indications are that the plans will eventually bear fruit. The accident to the R-38 last year showed the necessity of further investigation of stresses in rigid airships, and both the British and the U. S. Navy are giving consideration to this work.

Helicopters

The past few years have witnessed the return of attention to this type of aircraft and considerable activity existed throughout the world in the development of machines. A number of helicopters have been built which rose and remained in the air for short periods, some up to one hour, under control. Notable among the machines constructed and tested were the Pateras-Pescara, Karman, Damblanc, Oehmichen-Peugeot, Cooper-Hewitt, Brennan and the Berliner. The machines experimented with varied greatly in design, some being little more than propeller-type mechanisms, others had airplane fuselages with lifting screws mounted thereon, while still others were practically rotating wings. Up to date the work has been entirely on helicopters of possible military value. No promise of commercial uses has been noted.

Soaring Flight

Marked advances in soaring flight experiments have recently been made, activities in this field having been largely but not entirely confined to Germany. With development work on military types restricted by the terms of the peace treaty, German engineers gave considerable attention to experiments with man-carrying gliders.

Under the supervision of a central organization, and sponsored by many leading German aeronautical engineers, continued progress has been made in the length, duration and safety of flights. In September of 1921 Harth, a German experimenter, rose from a standstill and without assistance, in a motorless machine, flew and maneuvered under control for a period of 21 minutes and 37 seconds. During this flight he attained an altitude of about 200 feet above his starting point, finally landing at a point about 40 feet below the point of take-off.

Gliding, or soaring as they might be called, competi-

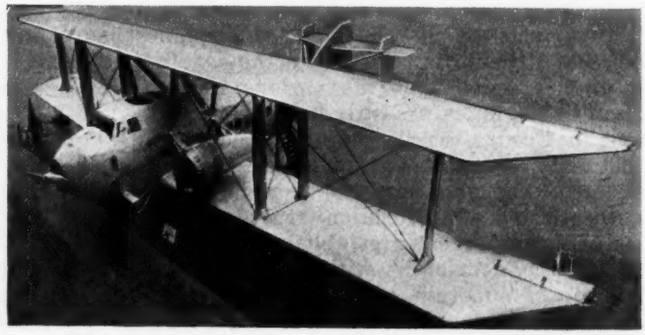


Fig. 2—Latecoere LAT4 commercial

tions have been held periodically. The interest taken in these is reflected by the numbers of machines entered, some forty types having been entered in the Rhoen competition of last year. The machines ranged from birdlike types of radical construction to those following conventional airplane design. The most successful machines have followed conventional lines, at least in their general appearance. The most striking feature in the construction of the successful machines is undoubtedly the extremely low weight of their structure. The "Aachen" soaring machine, a thick wing type suggestive of the Junker monoplane, has internally braced wings of plywood covered with fabric which weigh about one-third of a pound per square foot. This is about one-third to one-fourth of the weight of the wings of small airplanes.

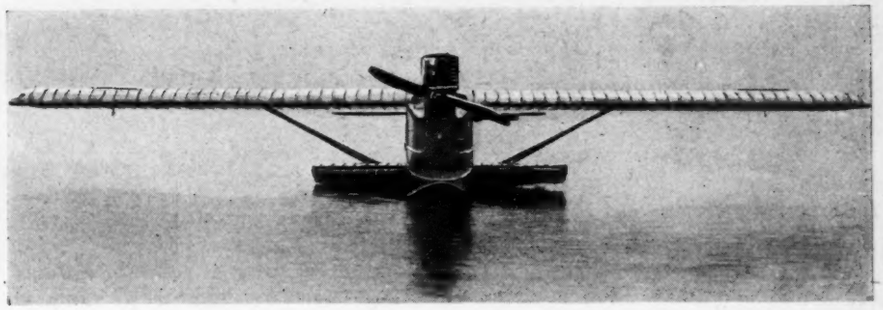


Fig. 4—Dornier "Dolphin" 6-passenger. (Note the balancing fins)

Three of the most successful German soaring machines, the Aachen, Bavaria and Harth, show the following average characteristics: Span, 33.33 feet; area, 163.0 sq. ft.; weight, empty, 131 pounds; weight, per square foot fully loaded, about 1.85 pounds. The success of the German experiments has created interest in other countries and the near future may be expected to show further progress in this field.

Engines

Development of larger engines, both air and water-cooled, has been steadily carried on. Water-cooled engines developing over 1000 horsepower have been built and tested, while one air-cooled engine rated at 1000 horsepower is understood to have been built experimentally. A general tendency toward larger engines, both here and abroad, is very marked, the increase in horsepower of air-cooled engines being the more noticeable. Attention has been given to the dirigible engine problem, and one American firm, Wright Aeronautical Corporation, recently developed a 400-horsepower dirigible engine with the unusually large bore of 7 inches. One American manufacturer is experimenting with an engine of the barrel type, having the cylinders parallel to the shaft. Through careful redesigning and refinement the economy and reliability of engines has steadily been improved. One American engine, the Aeromarine U-8-D, recently passed a 300-hour test run for the Navy, six times the customary acceptance test.

The development of superchargers has also been steadily continued and these have been brought to the point where they have thoroughly demonstrated their value. Certain airplanes are now being designed around engines equipped with superchargers. The Moss supercharger is practically out of the experimental stage and was instrumental in establishing the world's altitude record of 40,800 feet during the past year.

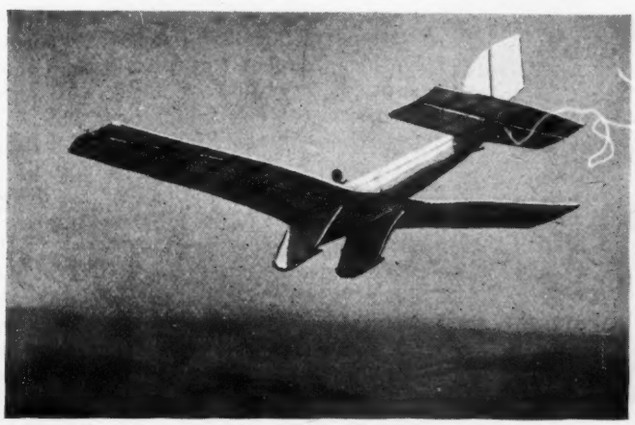


Fig. 3—Aachen Glider

The National Advisory Committee for Aeronautics is now conducting a series of tests of two other types of supercharger compressors, a positive displacement and a fan type, with the object of obtaining further improvement in performance and reduction of weight. As this work stands at present, engine power can be maintained within about 11 per cent of sea level power up to an altitude of 16,000 feet. This compares with a loss of about 50 to 55 per cent for the engine without supercharger.

Work on supercharging engines has also been carried on in Europe, particularly in France and Germany, although the United States is in the lead if altitudes attained may be taken as a criterion. The Rateau, a turbine type, upon which work was started in 1916, has been in experimental operation for the past few years and three sizes have been developed. Several German makes of superchargers, notably the Brown, Boveri & Co.; A. E. G. and Siemens-Shuckert, have been developed and operated satisfactorily.

Fuel Utilization

The National Advisory Committee, in conjunction with the Bureau of Standards, conducted numerous studies of flame propagation from which much has been learned. This work is being continued and its field extended. Experiments have also been conducted by this committee on a single cylinder Liberty engine converted for operation on fuel oil by direct injection. Experimental fuel spray nozzles and photographic apparatus for studying the tests have been developed and some experimental runs made using different fuel pumps and pistons.

A single cylinder test engine, specially designed for direct injection, has recently been constructed and will be used for extensive tests at an early date. This special engine is provided with means for varying valve timing, compression ratio and valve lift during operation. The results of the tests up to date have been very promising but it is yet too early in the experiments to form any conclusions. Some similar experimental work on direct injection is also being carried out in England.

In the course of investigation of carburetion problems, at the Bureau of Standards, a discovery was made which threw some light on hitherto unexplained engine failures. It was noted that formation of snow took place in the intake manifold, under certain atmospheric conditions, resulting in erratic performance of the engine.

Studies of accessories have been carried on and some attention has been given to engine fuel pumps designed to feed directly to the carbureter without the use of a gravity tank. At least two types have been developed and are operating more or less satisfactorily. Very little has been

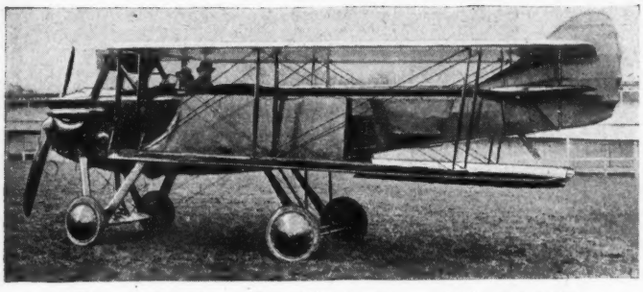


Fig. 5—Tampier automobile airplane. (Note the automobile running gear in rear)

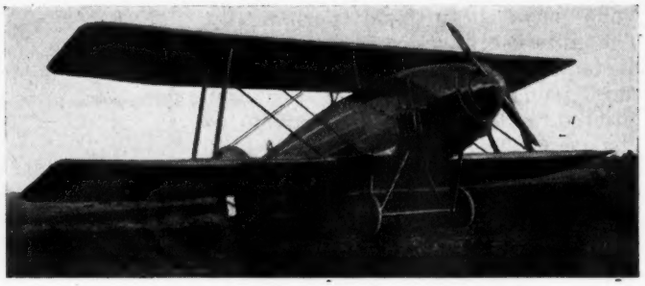


Fig. 6—Wibault 2Bn2 all-metal night bomber

done on further development of engine starters in the past year, although considerable activity took place in the years preceding. Apparently the starter situation is considered to be sufficiently advanced for the time being and further work rather discouraged until the rapid development of larger engines slows up. In addition, the satisfactory performance of hand magneto starter systems also tends to discourage additional work on mechanical or electro-mechanical starters. Then in many cases hand cranks are all that is necessary. Flight and laboratory tests of radiators have been continued and the general fund of information increased thereby. This work has now advanced to the stage where radiator performance can be predicted with considerable accuracy.

The most important work in the propeller field can probably be said to be the recent developments in variable pitch propellers. This work has been carried on both here and abroad. Noteworthy developments are the Hart (American), Paragon (American), Chauviere (French), Levasseur (French), as well as some Italian and German developments. Each of these designs has been proven more or less satisfactory and the variable pitch propeller problem may be said to be very close to complete solution. Although wooden blades, set in metal sockets, were used in most cases, some of the variable pitch propellers developed were constructed wholly of metal.

Investigation of materials other than wood for propeller construction has been carried on to quite some extent both in this country and in Europe. Propellers built of Micarta have now been developed to the point where they are of practical value. Propellers of steel and other materials are also being experimented with here and abroad, but are still in the experimental stages, with the possible exception of the Haw, steel reinforced, propeller.

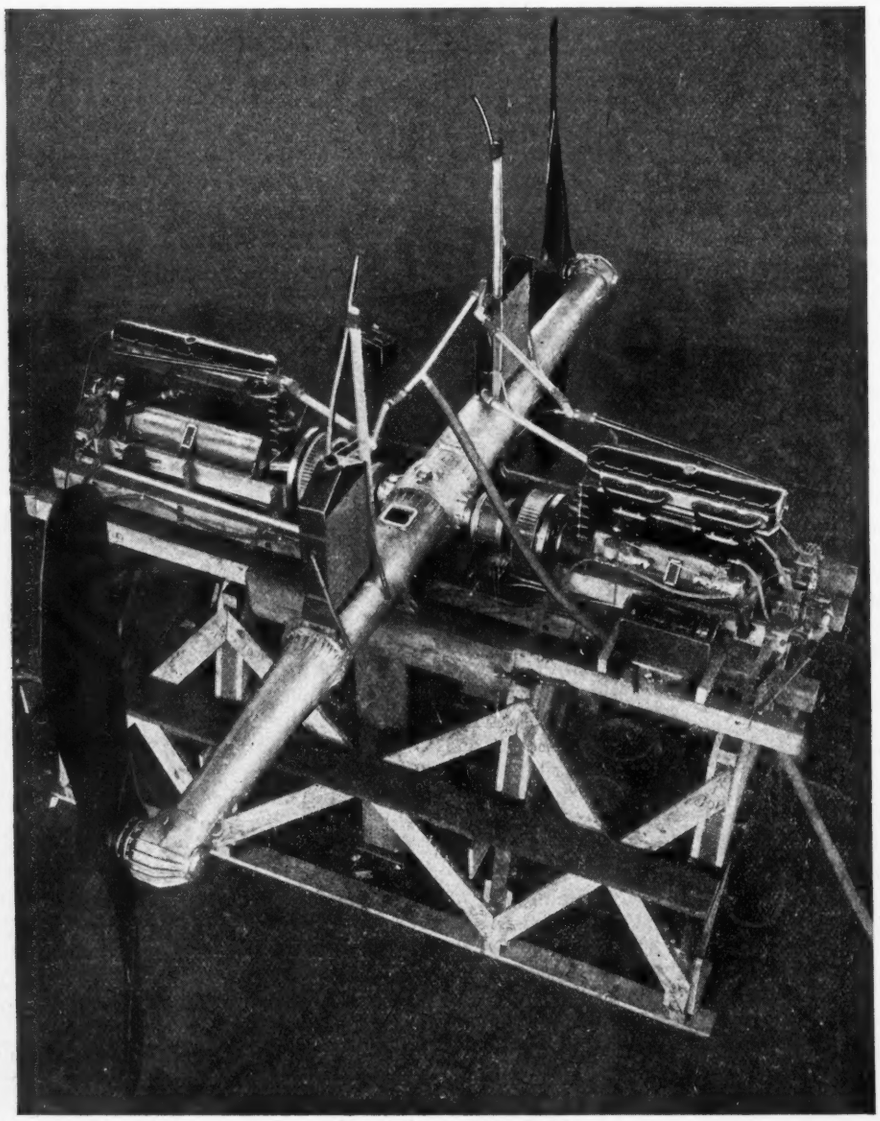


Fig. 7—Goodyear airship transmission

Instruments

Developments in the aircraft instrument field have chiefly been along the lines of refinement. Some new types and some important improvements in existing types have, however, been made. One American firm, Pioneer Instrument Company, placed on the market a novel type of gasoline gage, using a float and cord instead of the customary float and arm or screw. The dropping of the float, as the tank empties, unwinds the cord which, in turn, rotates the indicator needle. A new type of instrument, the "Flight indicator," consisting of a combined banking and turn indicator, was developed and marketed by two American and one French firms.

Air speed indicators of two new types have been developed, one for dirigible use, reading low speeds, the other for high-speed airplanes, reading up to 250 miles per hour. The Pioneer Company also developed a rate of climb indicator. A gyroscopic

sextant for aircraft use was developed in France, while the Bureau of Standards here developed a drift indicator of the optical type. The Bureau of Standards also developed an altimeter with automatic compensation for temperature changes, a rate of climb recorder and an angle of incidence recorder for test flight purposes. The National Advisory Committee for Aeronautics developed some special test apparatus for their free flight tests, notably a multiple recording manometer and a recording air speed indicator.

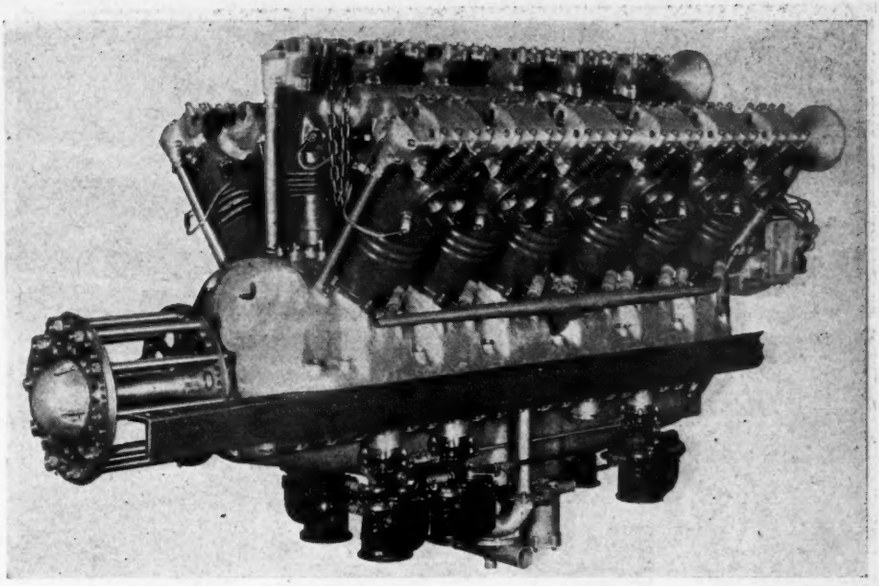


Fig. 8—U. S. Air Service Model "W" 700-hp. engine

Aerial Cameras and Photography

Aerial photography has undergone great development recently, and this field of use for aircraft promises to expand rapidly. An American firm, the Fairchild Aerial Camera Corporation, contributed largely to this through the development of an advanced type of automatic camera, and there has also been considerable activity in France and Germany. The Fairchild camera is controlled by an electric timing device which regulates the interval between the exposures to accord with the speed of the airplane. The individual photographs are thus spaced equal distances apart along the line of flight. This greatly increases the accuracy of the mosaic map and simplifies the work of building it up from the separate prints.

The importance of recent developments in this art is evidenced by the photographic mapping of the City of New York, from the Battery to Van Cortlandt Park, in a single flight of 69 minutes. The Dayton Wright Company developed a special type of airplane for photographic work. This machine has a fuselage of the closed type with windows on all sides, top and bottom to facilitate photographing from any position. A dark room is also provided so that cameras or plate holders may be loaded during flight or plates developed from time to time to check the progress of the work.

Landing Fields and Airways

Landing field engineering and the development of airways has been given some attention of late, although this phase of activity still lags behind others of the industry. One of the constructive steps, in this country, has been the publication, starting November of 1920, by the Hydrographic Office of the Navy, of a "Notice to Aviators." This publication is issued monthly, widely distributed, and each issue contains descriptive matter, collected from various sources, regarding aircraft landing fields throughout the country. At the same time, the Air Service, continuing the work which it started at the close of the war, has been studying and mapping terrain and emergency landing conditions over the country.

As a result, a valuable fund of information on landing

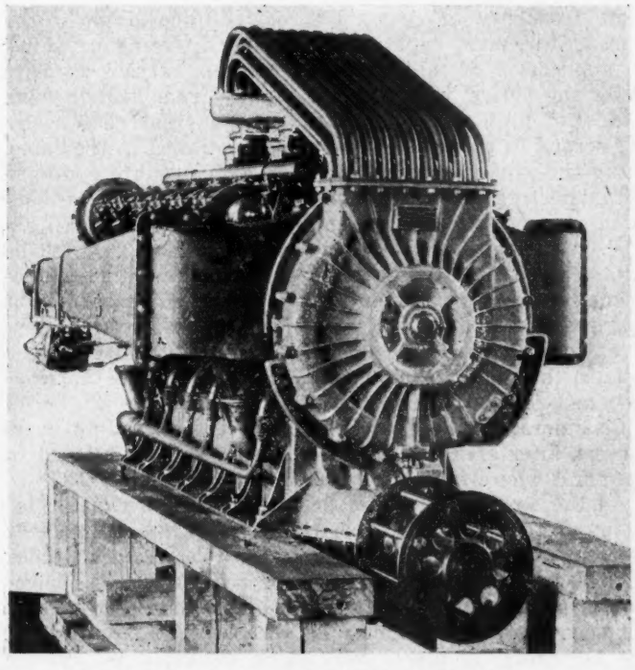


Fig. 9—Liberty-12 engine with G.E. (Moss) supercharger

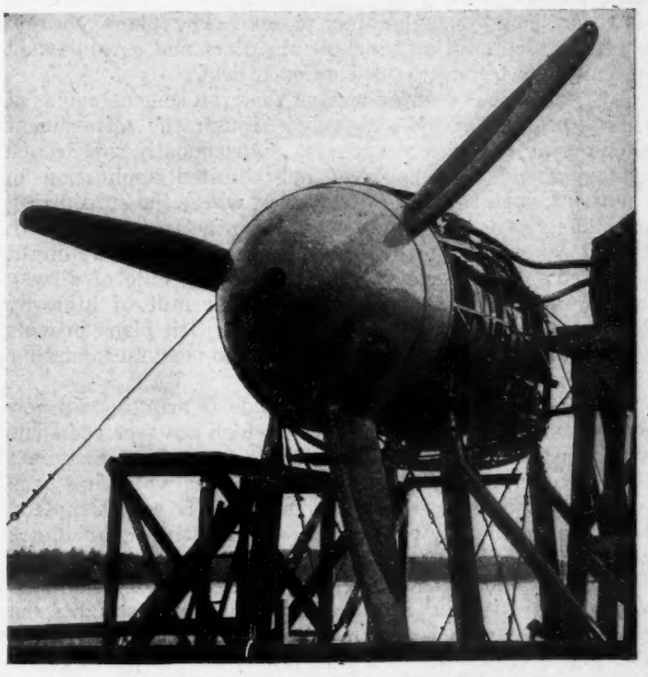


Fig. 10—Gallaudet 1200-hp. drive, using three Liberty engines

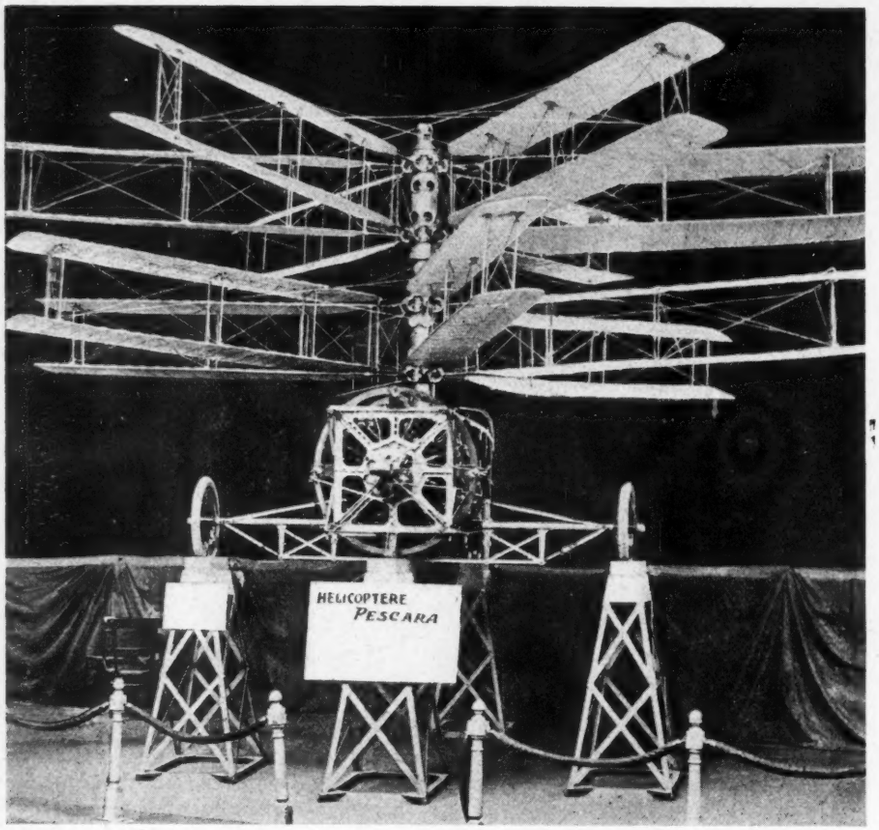


Fig. 12—Pateras-Pescara helicopter

places is steadily growing. Starting March of 1922, an arrangement was effected between the Weather Bureau and the Navy by which the latter daily broadcast, from Naval radio stations, complete weather reports and forecasts for the use of shipping and aircraft.

France and England have probably made the greatest advances in arrangement and equipment of landing fields. The French Government plans cover a comprehensive system of landing fields throughout that country. These range, through five classes, from a fully equipped field down to emergency landing places. The plans go into considerable detail and include the sizes and arrangement of buildings to be provided on each field.

The scale is so comprehensive that the scheme could, at this time, be carried out only through the government shouldering the major expenses. Consequently the French system would be capable of only limited application in countries, such as the United States, where the subsidizing of industries is less of an accepted practice. Even with the thoroughness of the French plans, however, it might be noted that the cost of construction per mile of airway is only a small fraction of the cost per mile of highway construction. Both the French and British plans provide for furnishing of service and supplies to machines, landing in Government fields, at fixed rates.

The increasing use of landing fields is bringing up new problems from time to time. One which has received some attention is the control of traffic at large terminals. At the Croydon field, near London, the system, which has been in satisfactory operation for some time, is very complete.

All machines leaving the field or alighting upon it are directed by a "traffic controller," stationed in a small house on an elevated platform giving full view of the field. Radio, Very's signal lights, megaphone or flashlights, as required, are used to communicate with machines in the air, and instructions are thus issued to the pilots desiring to land at the field. Field lights and signals are under the direction of the controller. the lights being operated directly from his office, while he is kept in touch with the radio operator by telephone. The system rather suggests that used at some of the large flying fields during the war, the chief difference being in the added facilities provided for issuing of instructions.

In both France and England, complete systems for communication between aircraft and the fields have been worked out and are now in experimental operation. Both visual and radio systems are being tried. Night landings are effected by the use of flare signals, all obstacles on the field being marked by lights, while wind direction is shown by an illuminated automatic Tee. Our own Air Mail Service and Air Service has also conducted some experiments along similar lines. The Air Service has been experimenting with a small searchlight, mounted on the airplane and controlled by the pilot, in place of parachute flares, for emergency landing use.

In hangars for landing fields, the Strauss (American) and the Service des Fabrications de l'Aeronautique (French) bascule door hangars are worthy of note. Each of these types makes use of a motor for operating the large hangar doors. The U. S. Navy constructed, at Lakehurst, N. J., the largest airship hangar in the world which is capable of housing two large rigids.

Navigation

The Loth cable, developed by Lieut. A. W. Loth of the French Navy, represents one of the most important of recent developments in aerial navigation. The fundamental principle of the Loth system is based upon detection of the magnetic field surrounding a cable transmitting high frequency current. The device follows along the lines of previous experiments in the directing of ships. In application of this system, a cable is carried on poles along the entire length of the airway from field to field. A flow of high frequency alternating current (600 cycles per second in the experiments) is maintained in the cable, using the ground for return. The airplanes are equipped with detecting mechanism consisting of three loops of insulated copper wire at right angles to each other, making a horizontal, longitudinal and a transverse loop. By means of a selector switch, these loops are connected to a telephone receiver, the switch being so arranged that the pilot can listen in on any loop. By listening in on the successive loops and estimating the relative intensity of the sounds, the pilot can determine his position *both horizontally and vertically* with relation to the cable.

Considerable trouble was at first encountered in overcoming interferences but the system is now developed to the point where these give little or no trouble.

As the work stands, the field of the cable can be detected up to an altitude of nearly 10,000 feet, and sufficient detection for complete control is possible up to altitudes of 6000 to 7000 feet. While at the latter altitudes, detection is possible for a distance on either side of the cable about equal to the altitude. As the ground is approached, the horizontal distance over which detection is possible increases until, close to the ground, the cable can be found

by the apparatus at a distance of about nine miles from either side of it. This system has been hailed by the French as mastering the problem of operating through fogs and it undoubtedly goes far toward this solution.

While the Loth system was being developed in France, attention was also being given to radio direction finding experiments, both here and in France, with much success. This system has the advantage, over the Loth cable, that it is not so expensive to install and can be used over large bodies of water where Loth cables are not practicable. On the other hand, the Loth system greatly simplifies the work of the pilot. With radio direction finding equipment, "beacon" stations, located at various points, transmit periodic signals. By taking bearings of each of two stations, the pilot is enabled to determine his position. Three "beacon" stations were in experimental operation last year, near the approaches to New York harbor, in addition to the numerous radio stations on both coasts which give bearings upon request. Some experimental "beacon" stations were also in use in England and France.

Another system, which is being experimented with in this country, England and France, makes use of beacon lights for navigation at night. Powerful lights are placed at landing fields and along the airway. These are arranged to either flash periodically, after the manner of lighthouses, or are pointed upward and kept in motion so that the beam of light describes an arc through the sky. Bearings are taken visually from the beacons by pilots.

Some very elaborate beacons of the lighthouse type were installed experimentally in France last year and some others have been installed experimentally here and in Great Britain. The lighthouse constructed at Dijon, France, is designed to be visible for a radius of 65 miles in normal weather, or 130 to 200 miles with very clear weather (at a height of about 6000 feet). This light is rated at 1000 million candlepower, the house being about 18 feet in diameter and about 30 feet high.

Considerable attention has been given, in Europe, to the collection and dissemination of meteorological information along the course of aircraft. Plans have been made, and are now being put into execution, in France and England, for the collection of this information and its transmission to aircraft en route by radio. Apparently all of the plans considered so far contemplate transmission of the digested reports to pilots. This brings to mind the question of whether it would not be more convenient for the pilot if a system of transmitting flying instructions could be used in place of the broadcast reports. The whole proposition is, however, in a more or less embryonic state at present.

Another necessity of aerial navigation which is now being taken up is the creation of maps suitable for this purpose. Conferences on aerial navigation, in Europe, have standardized three classes of maps as follows: *General maps*, Mercator's projection on scale of 3.cm per degree longitude; *Normal maps*, scale of 1 : 200,000; *Miscellaneous* maps and additional maps which navigators may desire to use, no scales or other standards yet fixed. Some progress has been made in the standardization of the symbols used. Tints, as against shading, have been selected to indicate altitudes.

Aerodynamic Research

The field of aerodynamic research has witnessed continued progress both here and abroad. In the United States particularly, activity in this work has increased since the end of the war instead of decreasing as in some other branches of the aircraft field. Work on tests of new wing curves has been continued and great improvement has been made, in gradual steps. Research has been extended well into the field of thick and semi-thick wing sections and tapered wings, showing these to be very promising. Full scale tests of airplanes and parts are being conducted here and in Europe, which will increase our knowledge of full size performance.

The Handley Page slotted wing and the German slotted wings may be numbered among the interesting developments of the past couple of years. From the purely military standpoint, the slotted wings have been rather disappointing up to date. While very high lift values have been obtained by the use of such wings, their application to military machines is being retarded by the fact that their properties at climbing angles did not permit substantial change in wing area. Remarkably low speeds have, however, been attained by the use of the Handley Page wing. The "Alula," a high lift wing of unusual shape, is being experimented with in England and has shown exceptionally high efficiency in preliminary tests.

Aerodynamic Theory

Important contributions to aerodynamic theory have been made by Prandl, Karman, Joukowski, De Bothezat and others. Recent papers showed marked advances in the reduction of the science of aerodynamics to a mathematical basis. Experimental investigation of ground interference with wings, conducted here, in England and in Germany, showed the resistance of wings to decrease and their lift to increase with proximity to the ground.

The National Advisory Committee for Aeronautics is now constructing, at Langley Field, a compressed air wind tunnel which will permit the making of tests under conditions dynamically similar to those of full size machines. The Committee also has started a comprehensive series of free flight tests on full scale airplanes and parts. Each of these plans promises to decrease the present errors in calculating full size performance from test results. Work

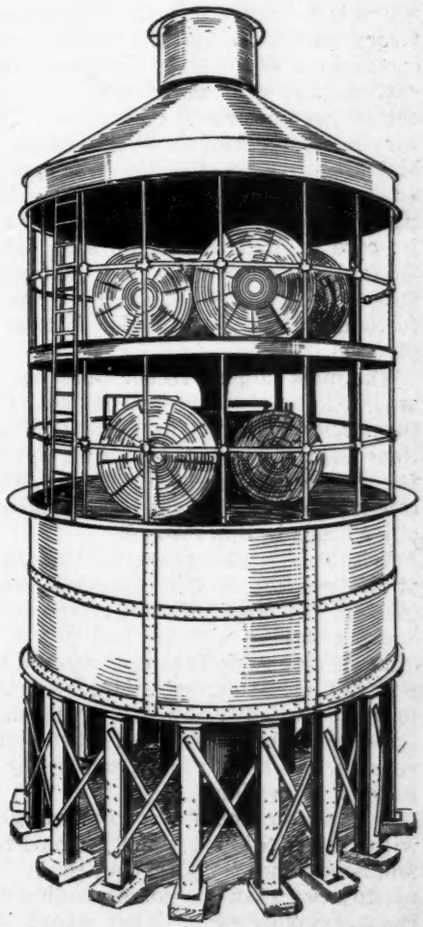


Fig. 11 — Dijon (France) aerial lighthouse

on the standardization of wind tunnels, by testing of standard cylinders, wing curves, etc., has also been started by this Committee. In addition to these activities, numerous tests of pressure distribution, over surfaces of wings, ailerons, etc., have been carried out. Some full scale tests have also been carried out in Europe. A new wind tunnel 10 ft. in diameter and equipped for speeds of up to 90 miles per hour, is now being constructed at the Bureau of Standards.

Wind tunnel tests of the characteristics of model propellers have been continued at the Leland Stanford University and much additional data obtained. These results are being published in convenient form for designers' use, by the National Advisory Committee as the work proceeds. The high speed wind tunnel of the Air Service, at McCook Field, Dayton, has furnished information on the characteristics of propeller sections at speeds up to 450 miles per hour, showing considerable movement of the "no lift angle" and other changes as the higher speeds were reached.

Within the past couple of years additional information on British and French tests of tandem propellers have been made available by their publication. Eiffel tests indicated the practicability of using two similar propellers in tandem, but showed that tandem propellers should be arranged to rotate in opposite directions.

Materials

Experimental work on practically all classes of aircraft materials has progressed steadily, but no particularly interesting results have been noted recently. Little, if any, has been added to our existing knowledge of duralumin, but the Germans have been working for some time on a magnesium alloy. Samples of this alloy, received in the United States, showed high strength for their weight, which is lower than that of duralumin. The National Advisory Committee and the Forest Products Laboratory, in continuance of their tests of glues, are now experimenting with animal glue and rubber in benzine, in an effort to obtain greater water resistance. Tests on the effect of varying the pressure used in glueing showed medium and high pressures to give the best results.

An American firm has placed on the market, under the trade name of "Plymetl," a material composed of a 5/16-in. core of wood faced, on each side, with No. 30 gage black sheet steel. The two materials are cemented together and sold in sheets free from any other means of fastening. The sheets resist damage and fire better than plywood.

The most notable recent work has probably been in the applications of materials rather than in the materials themselves. Among these new applications might be mentioned the experimental use of plywood in place of cloth for wing covering, the use of vulcanized fiber for fuselage construction, and some developments mentioned under other heads in this résumé.

Within the past year the Underwriters' Laboratories, at the request of the insurance companies, arranged to take up the work of inspecting and classifying aircraft and registering aircraft and pilots. Plans for the handling of this work have been worked out and were recently put into operation, but sufficient time has not yet elapsed to make available any substantial data on aircraft risks. Conditions abroad are somewhat similar and it will be a year or two before any trustworthy information on this subject is available.

Insurance premiums are accordingly high in most cases, with the notable exception of the French companies' premiums on merchandise carried by air. These rates are much lower than the corresponding rates for coverage of goods transported by other means.

As an example, for a given condition the premium of 1.50 francs per thousand charged for coverage of goods carried by air compares with the rate of 7.0 francs per thousand for goods carried by rail or boat. While the explanation of the difference is not given, it can probably be assumed as due to the greater care with which aircraft shipments are generally handled and to the elimination of pilfering.

Aircraft insurance pools have been organized in several countries and are now making studies of hazards. So far it has been learned that radial engines are poorer risks than other types, that water types of aircraft are better risks than land types and that much importance must be attached to the experience and record of the pilot. Differential rates are being worked out to apply to these conditions.

Operating Cost Studies

The first really reliable information on the cost of operating aircraft commercially became available with the publication of the monthly reports of the U. S. Air Mail Service. These have been continued and constitute to-day the most complete and reliable source of information on this subject. The consolidated report for the twelve months ending June, 1921, showed the following averages for the year: Total operating cost per hour of flight, $71.13; total cost per mile of flight, $0.8475. These costs were divided: overhead, 23.8 per cent; flying, 29.8 per cent; maintenance, 46.4 per cent. The more recent monthly reports show a tendency toward reduction of these figures, the cost dropping to $58.35 per hour and $0.64 per mile during March of this year. In considering these figures it should be remembered that the Air Mail machines are obsolete DH-4 Army types converted to mail carrying uses, entirely unsuited to their work, but the only craft available under the appropriations. The latest commercial airplanes are designed to carry about *five times* the capacity of these machines with practically the same horsepower.

The Aeromarine Airways, operating the largest fleet of commercial aircraft in this country, has now been in operation for about 19 or 20 months. This fleet has been added to until it now consists of 29 flying boats ranging from 5 to 14 passengers in capacity. Consequently, the following figures on operating costs, recently given publicity by this firm, are of particular interest: Total cost of operating converted Navy flying boats (exclusive of administration and advertising), five-passenger, $29.98 per hour; eleven-passenger, $71.12 per hour.

Late in 1920 the British Air Conference made a comprehensive study of operating costs of many types of airplanes. While this information is now old, it is worthy of mention on account of never having been published in this country. The figures gave the cost of operating *commercial* airplanes as 9.5 cents per passenger mile or .038 cents per pound mile. Using the Air Mail costs as a basis, the writer estimated that the latest types of commercial airplanes could be operated at a total cost of 6.5 cents per passenger mile or .030 to .032 cents per pound mile. Capt. de Haviland recently made a very complete study of this subject and stated that these figures are not only conservative, but on the high side. All of the latter figures assume fully loaded machines.

Commercial Operations

Although commercial operation of airships has been dormant during the past few years, commercial aviation has been slowly developing. This development has been slower than was generally anticipated by the industry, but some substantial progress has been made. The seven

countries on which figures are available show the following activity in this field during 1921:

Country	Number of flights	Total miles	Passengers carried	Pounds freight carried
*Belgium	1,224	161,800	2,199	28,000
Canada	10,386	294,449	9,153	79,850
France	6,221	1,457,437	10,336	396,000
Germany	....	1,029,000	6,820	67,700
*Great Britain ...	22,676	533,700	41,956	94,000
*Holland	1,000	289,000	1,511	68,100
†United States ...	130,736	2,907,245	122,512	123,227
Totals	....	6,672,631	194,487	856,877

*Incomplete figures.

†Unofficial estimate compiled by the Aero. Chamber of Commerce.

For a considerable period practically all operations of commercial airplanes, including those subsidized by government grants, were operated at a loss to the firms. These losses have gradually been decreased until, in many cases, the operators now show small profits. The largest American line, Aeromarine Airways, recently found it necessary to turn away some prospective passengers owing to the growth of their business exceeding that anticipated. Some curves, showing the growth of the French air lines, are reproduced here from a paper read (before the Premier Congres International de la Navigation Aerienne) by Albert Tete last year. British reports showed the monthly efficiency of air lines performance to range from 54 per cent to 100 per cent during a period of several months. The monthly performance of the U. S. Air Mail Service ranged from 77 per cent to 99.3 per cent efficient during the year 1921, while the Rumpler Air Lines, in Germany, showed efficiencies ranging from 91.6 per cent to 100 per cent during an eight months period. In general these figures seem to be gradually improving as experience is gained. Of all the lines the U. S. Air Mail Service is the most unique from point of mileage, regularity and varied weather conditions to be met.

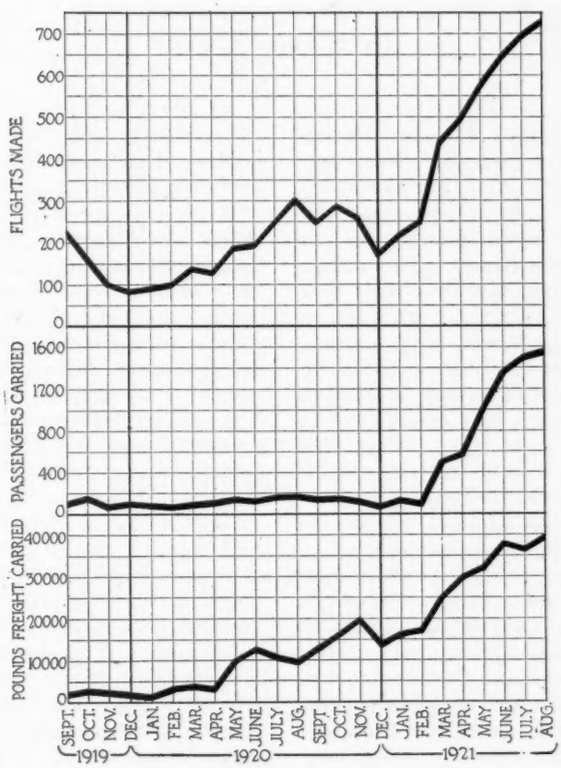


Fig. 13—Growth of the French Airlines

Last year witnessed 114 accidents to aircraft in the United States, resulting in 49 deaths and more or less serious injuries to 89. In 48 of these cases there were no casualties and only in 39 were there any fatalities. While no government body, charged with supervision of aircraft, exists in this country, the Aeronautical Chamber of Commerce in co-operation with the Army, Navy, Air Mail and others, tabulated the causes of each accident so far as they could be obtained. These were charged against chiefly, stunting; lack of supervision; lack of proper landing facilities; lack of weather reports; faults of engines and machines (many of which inspection would have avoided) and some appeared to have been unavoidable. During this period the 125 commercial aircraft operating firms flew 2,907,245 miles carrying 122,512 passengers without any fatal accidents. Two very serious airship accidents occurred during the past twelve months, the loss of the R-38 in England and of the "Roma" here. The first appears to have been clearly due to structural failure and suggests the necessity of further study of methods of stress analysis of rigids. The "Roma" disaster was probably due to an unfortunate combination of several circumstances rather than any one cause.

Between January 1 and September 15, 1921, French aerial navigation companies flew 1,003,000 miles during which 4 fatal accidents occurred and 8 accidents resulting in injuries to one or more persons. The report of the Canadian Air Board for 1921 showed a total of 479,929 miles of civilian and government civil flying during the year. In this period 18 accidents happened, of which 4 resulted in deaths, 3 in injuries and the remaining 11 did not involve either death or injury.

Last year the Gallaudet Company constructed, for the U. S. Navy, a power plant unit of particular interest. This unit, containing three Liberty engines and driving, through clutches, one 18-ft. propeller, has been tested out and performed very satisfactorily. It is entirely streamlined and will be used in the large flying boat which is being constructed at the Philadelphia Navy Yard. The Goodyear Tire & Rubber Company also developed a transmission mechanism, for dirigible use, in which the two engines were located inside of the car driving, through clutches, two propellers mounted on tubular arms projecting outside of the car.

The Avelene electro-mechanical airplane control, developed in France, makes use of a mercury type of balance and solenoid controlled compressed air motor for operating both ailerons and elevators. This device has gone through extensive tests and is understood to have performed very well. The U. S. Navy has developed a kite antenna, for the use of seaplanes while on the surface of the water, which was found to not only permit the use of radio under this condition, but to increase the range about 25 per cent over the normal range while in the air. This device is expected to be of great value to aircraft making forced landings on the surface of water.

The installation, in a number of Air Mail airplanes, of carbon tetrachloride spray systems is important from a safety standpoint. These are designed to permit the pilot to discharge this liquid over the engine in case of fire. No occasion has yet arisen to demonstrate the value of this device although some tests made by the Air Service indicated that it would be effective. The Foamite Firefoam Company is also experimenting with a system for spraying fire extinguishing foam over the engine in a similar manner.

New uses for aircraft continue to be found from time to time. The Department of Agriculture recently conducted some experiments using airplanes for spraying calcium arsenate over cotton fields. These were carried out as part of the work on the boll weevil scourge and were regarded as very successful.

Better Economy and Flexibility Are Chief Aims of Engine Development

Cars which will average forty miles per gallon of fuel may soon be the rule. Research and development work is tending in that direction. Lower average speed and higher torque desirable from economy standpoint. Development of non-throttling engines in process by several engineers.

By Herbert Chase

PRESENT day automotive engines of the conventional type lack certain highly desirable characteristics,—consequently there are afoot persistent efforts to bring about a change to a new type or to improve the present type with only such changes as are absolutely essential to better performance. The industry responds but little to those who urge reversion to a different type or types, but is lending an ear, at least, in the case of the more progressive elements, to promising improvements which involve less radical departures. Research and development is proceeding along both lines and should be followed and encouraged by executives as well as by engineers, for changes must come. They will be forced by change of conditions and those who anticipate these conditions will profit accordingly.

The chief drawback to the conventional type is its lack of high economy in fuel under the conditions of average use. Even when run under most favorable conditions of load and speed its consumption of fuel is higher than it need be if favorable conditions could be brought about, especially in respect to the nature of the fuel available. Some well-informed engineers believe that the car which will average upward of 40 miles per gallon of fuel will be quite the average rather than the exception within a very few years.

Of scarcely less importance than fuel economy but frequently overlooked is the relatively low torque which the average engine exerts, especially at low speeds. It is in fact a comparative lack of flexibility in the internal combustion engine inherent in the steam engine which has enabled the latter type of prime mover to hold its own in heavy traction work, especially in railway locomotives, in spite of its relatively low fuel economy under the conditions of normal use.

Although some properly make a distinction between "pure" research and development work, the dividing line is not always well defined, consequently it is proposed to outline some promising development work which is now in hand or in contemplation, and in connection with this to consider several items of research of a closely related nature.

The Constant Compression Engine

WHAT many engineers regard as the most promising line of development of the near future in automotive engines is one which involves the abandonment of control by throttle and the use of constant compression, the power output being varied by control of the quantity of the fuel fed while the total cylinder charge remains substantially constant. The use of this type of engine involves localizing the fresh charge in a pocket adjacent to the spark plug at low loads. Operation at full load will be substantially the same as in present engines. There are several methods of accomplishing practically the same result in this type of engine, and some of them have been already described in these columns. Of particular interest in this connection are Ricardo's experiments, which were described in AUTOMOTIVE INDUSTRIES for February 24, and July 14, 1921, a sectional view of one of Ricardo's localized charge engines is given in Fig. 1. In the issue of June 16, 1921, was a brief description and diagramatic cut of the Newcomb two-stroke constant compression engine which performs substantially the same function as the Ricardo engine but by employing a quite different construction. It will be recalled that in the Ricardo engine the combustible mixture is taken into a chamber in the head through a separate valve while the main charge of air enters through a larger valve similar in size and arrangement to the ordinary inlet valve. The rich mixture is ignited in the chamber in the head and passes through a Venturi tube into the main combustion chamber where the additional air for complete combustion is present. In this engine the quantity of air taken in through the main inlet valve is nearly constant while the quantity of mixture taken in through the valve in the head compartment is varied in proportion to the load. In this engine the fuel consumption per i. hp. hr. was less than 00.4 lbs., while at full load it was approximately 0.5 lbs. With the same engine running under throttle in the normal way the consumption increased to 0.65 lbs. at low load. The difference on a basis of brake hp. was, of course, considerably greater, owing to the fact that engine friction and pumping losses are nearly constant at a given speed whether the load be light or heavy.

This is indicative of the chief advantages of the localized charge, constant compression, or non-throttling type of engine as it is variously called. In other words an engine of this type is much more efficient than the conventional type in which the economy at low loads is always much less than at full load, whereas the engine runs most of the time, especially in passenger car installations, under very low load conditions. Thus the advantages of high economy under practical operating conditions are much in favor of the non-throttling type.

The Newcomb engine, referred to above, possesses practically the same advantage although it is of quite different design. Like all two-stroke engines it is of the

constant compression type owing to the fact that exhaust products are expelled substantially in proportion to the new charge entering the cylinder so that the total weight of the charge at the beginning of compression is practically constant regardless of the load. In the Newcomb engine, however, the charge does not enter through the conventional inlet port near the base of the cylinder, but through a poppet valve in an L-head. At part loads the charge is localized in the L and is ignited by a spark plug at this point. The engine has other features (which we are not at liberty to describe at this time), the purpose of which is to minimize admixture of the fresh charge with residual productions of combustion in the cylinder, and prevent waste of the charge through the exhaust ports. We are not in possession of definite figures on performance of this engine, but understand that its economy at low loads is much superior to that of the ordinary throttling four stroke engine. The writer has ridden in a ½-ton truck chassis fitted with a single cylinder engine of the Newcomb type, and found it to show excellent performance on the road. It is said to be capable of running light from 70 to 80 miles per gallon of gasoline. This in indicative of the possibilities of a constant compression engine using a localized charge and explains the reason why several capable engineers are working upon the development of engines of that type.

A majority of the constant compression engines which have come to our notice are still in the development stage and particulars concerning them have not been released for publication. It may be said, however, that various methods are used to localize the charge. In at least one case this is accomplished by fuel injection in a very simple and effective manner, and by means of a system which can be easily applied to existing conventional engines, probably with the result of doubling the distance they will run per gallon of fuel consumed.

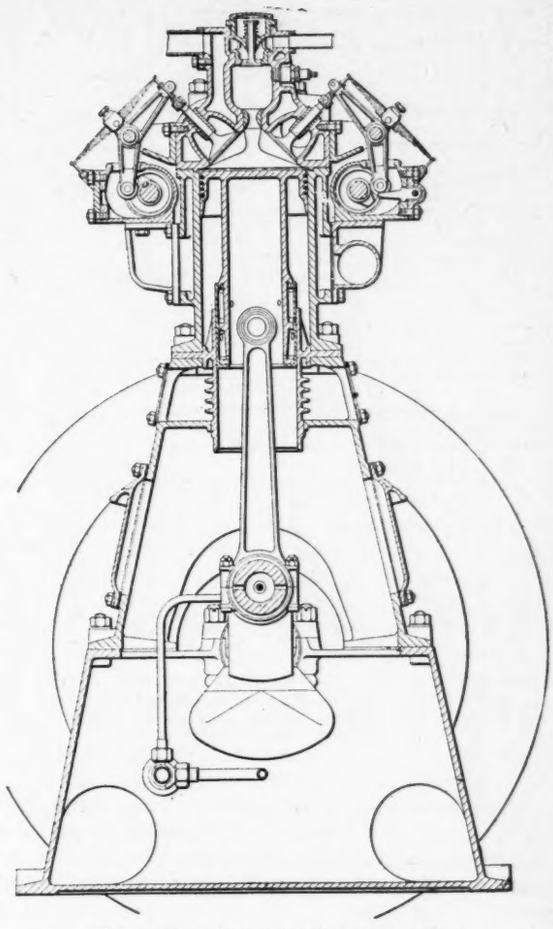


Fig. 1—Ricardo stratified charge engine

Supercharging Engines

THE question of supercharging engines has been considered chiefly from the standpoint of application to aircraft, and especially, in that case, for the purpose of maintaining at high altitudes the power which the engines are capable of developing at ground level. Considerable work has been done along this line by the National Advisory Committee for Aeronautics which has been engaged in the development of a Roots type positively driven displacement compressor. This supercharger has been operated as an experimental unit in connection with the Liberty engine and is now being installed in an airplane for free flight tests. It is reported to have shown promising results and to have an efficiency which is much higher than any other type of compressors used for the same purpose.

The N. A. C. A. is continuing the development of a positively driven fan-type supercharger having a fan construction with sufficiently low moment of inertia to permit of positive connection to the engine crankshaft. Changes are being made in this supercharger and it is expected that material improvements both in efficiency and capacity will make it suitable for application to the Liberty engine.

An interesting discussion of supercharging engines and their application to various forms of automotive vehicles is contained in a paper entitled Superchanging Engines by C. H. T. Alston,* from which the curves given in Fig. 2 are taken. The curves are intended to show the effect of operating the supercharged engine A in comparison with a normal type of engine B of a slightly larger cylinder capacity but developing the same maximum bhp. The maximum power with the supercharged engine is obtained with a much reduced speed or in other words the torque at low speeds is higher. Space here is not sufficient to discuss the advantages and disadvantages of the supercharging engine referred to by Alston, but certain of his conclusions will be given:

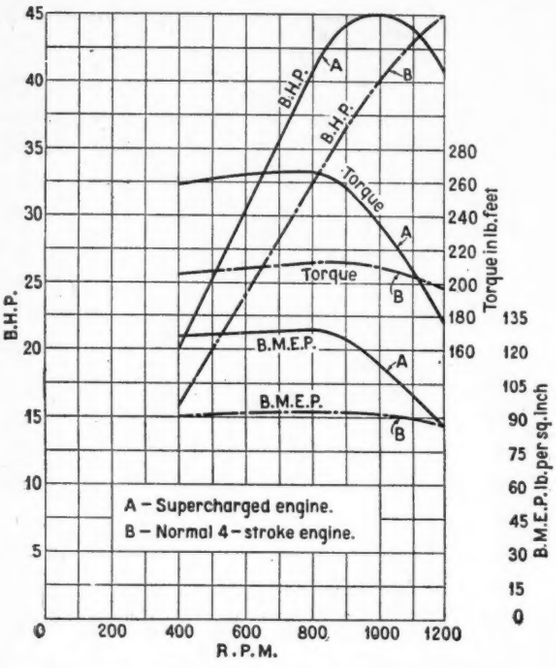
"For aircraft engines, intended for commercial aviation and flying at comparatively low altitudes for long distances, supercharging does not appear to offer any particular advantages, and will probably consume more fuel per mile flown and carry less cargo. It is quite a different proposition from that of the fighter type of machine for war purposes. In the latter case the larger hp. that could be exerted for climbing and attaining a very high 'ceiling' would be a great gain even if the fuel consumed should be more."

For road vehicles Alston concludes that supercharging offers great advantages providing the method and apparatus for carrying it out do not detract from it. Only a slight amount of extra weight is entailed while the torque is greatly increased, giving quick starting and acceleration and great hill climbing ability. He says further:

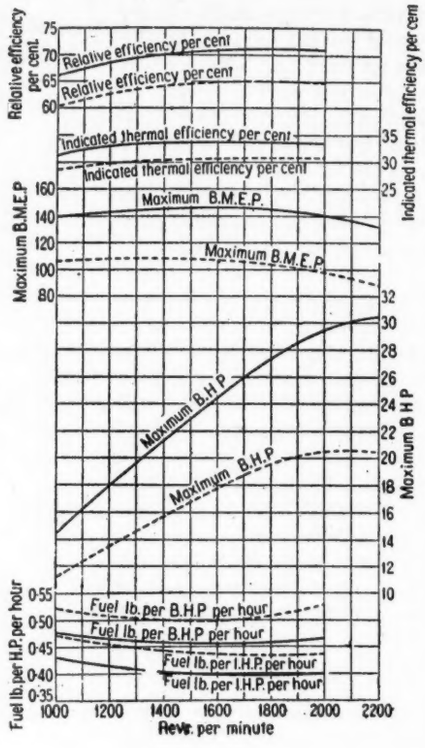
"There should be, moreover, a considerable increase in the ton mileage per gallon, as the conditions under which the engine is operating are, for the greater part of the time, more favorable to engine efficiency. It should render touring cars of moderate engine power pleasanter to drive, because more running can be accomplished on top gear without much loss of speed."

Ricardo has conducted numerous experiments with supercharging engines, and the results of some of his

*The Automobile Engineer, October, 1921.



Above—Fig. 2—Relative performance of engines of equal power with and without supercharging. At right.—Fig. 3—Performance curves of Ricardo engine with and without supercharging


Relative efficiency per cent
Indicated thermal efficiency per cent
Maximum B.M.E.P.
Maximum B.H.P.
Fuel lb. per B.H.P. per hour
Fuel lb. per I.H.P. per hour
Revs. per minute

tests were printed in AUTOMOTIVE INDUSTRIES for July 14, 1921. Some of the results of these tests are given in the accompanying curves, Fig. 3. For details in this connection the reader should refer to the article in question.

Higher Compression Ratios

THE advantages of higher compression ratio in respect to power and thermal efficiency have been referred to many times in these columns in connection with the work of Ricardo and others. From the curves in Fig. 4 plotted from the results of Ricardo's work it will be seen that indicated mean pressure and thermal efficiency increase in almost direct proportion to the increase in compression ratio. The curves in question apply to 95 per cent ethyl alcohol which is capable of operation with compression ratios of nearly 8 to 1 without detonation. Similar results with other fuels are obtained up to the compression pressures at which detonation occurs.

As we have noted elsewhere in this issue in connection with our articles on the subjects of fuel and combustion phenomena, the tendency of the fuel to detonate is a limiting factor which cannot be controlled by the engine designer. It is possible, however, to decrease the tendency to detonation by diluting the charge with an inert gas such as the products of combustion, and the use of these products or of steam generated by the introduction of water with the fuel is worthy of careful consideration. In an engine of given size with a given compression ratio the maximum power may be reduced by the use of a diluent, but the thermal efficiency can be materially increased by this means. On the other hand the possible increase in compression pressures when diluents are used may more than offset any loss of power due to the decreased volume of air which is available to support combustion when the diluent is mixed with the incoming charge. This is a subject which requires further research work but has considerable promise of success.

The relative scarcity and consequent high cost of the more volatile fuels, especially gasoline, have led to considerable research and development work with a view to producing engines which will burn economically less volatile and much cheaper fuels which are often available in large quantities. Diesel engines and so-called semi-Diesel or surface ignition types have been successfully developed for marine use and for stationary or semi-portable applications, but few attempts have been made to adapt engines of this type to other automotive purposes. One French manufacturer has, however, developed an automobile engine intended particularly for colonial use in localities where gasoline is very expensive. This is the Peugeot-Tartrais engine which was described in AUTOMOTIVE INDUSTRIES for February 9, 1922. It operates on a two-stroke cycle and employs solid fuel injection. A separate pump is used for scavenging the cylinders and supplying the air for combustion of the fuel, which can be almost anything from kerosene to crude oil or various coal tar products, vegetable or animal oils. The head of this engine is made of a high grade heat resisting steel, and is not water jacketed. It is consequently maintained at a high temperature. The engine is apparently operated at fairly high compression pressures and is said to consume 0.397 lbs. of fuel per hp. hr. under full load and less than ½ lb. per hp. hr. at quarter load. One engine of this type is said to have been used successfully in a Paris bus chassis.

Another heavy fuel engine which is said to be capable of adaptation to automotive purposes is the compound expansion Sperry Diesel engine. This engine was described in AUTOMOTIVE INDUSTRIES for March 16, 1922. It employs solid injection. Precise data concerning its performance are lacking.

Aircraft Engine Development

ON account of the fire hazard which arises as a result of the use of highly volatile fuels for aircraft, much study has been given to the possible development of heavy oil engines for this class of service. The National Advisory Committee for Aeronautics has been working along this line for several years and has recently completed a single cylinder experimental engine with means for varying the compression ratio, valve timing and valve lift. This engine is so arranged as to be readily fitted with combustion chambers of varying shape. It is to be used in securing data on the basis of which a practical aircraft engine can be built.

The N. A. C. A. have for several months been operating a single cylinder Liberty engine arranged to operate with fuel injection. This engine is said to have given an indicated fuel economy which is reasonably satisfactory considering the unfavorable shape of the combustion chamber for an injection engine. The in-

dicated fuel economy is reported to be practically constant for all loads down to approximately ⅛ full load. The power output thus far obtained is about 70 per cent of the maximum possible with a carburetted mixture. This is attributed to the fact that the piston used extends so far into the combustion chamber as to prevent utilization of the whole air charge.

Solid Injection

ONE of the chief disadvantages with the earlier conventional type of Diesel engine is the very high air pressure required for injecting the fuel, and the consequent necessity for using a multiple stage air compressor which resulted in low mechanical efficiency of the complete engine, as well as in considerable complication. To avoid this disadvantage many solid injection Diesel engines have been developed in which the fuel is forced directly into the engine cylinder without the use of high pressure air. There is said to be difficulty in securing complete combustion with this type. Much depends upon the shape of the spray, and on this account the N. A. C. A. has been making experiments with liquid spray produced under various conditions corresponding to those in an injection engine. Apparatus for taking photographs of the spray at a rate of 1350 per second was first developed but was not found entirely satisfactory. It is being redesigned to increase the rate of photographing to 5000 per second. With this new apparatus it is expected that it will be possible to follow any individual particle of the spray from the instant it leaves the nozzle to the time it becomes invisible. This work is said to be proving its importance by results already obtained which show considerable variation in spray characteristics as affected by the density of the medium into which the spray is injected.

Other research and development work on heavy fuel engines is known to be in progress in various laboratories but the results of most of this work have not yet been made public.

A Brayton Cycle Engine

AT least one investigator, P. A. Lawrence, is experimenting with an engine operating on the constant pressure cycle in which the air is compressed and delivered from the working cylinder into an external air chamber after which it is readmitted to the cylinder. As it enters the cylinder fuel is injected into the air stream where it is ignited either by a spark plug or by the high temperature of the walls or the air itself. The operation of an engine of this type results in a card similar to that of a steam engine, and the cut-off can be varied as in the case of a steam engine, providing a suitable air reservoir is connected. The Brayton engine which operated on the constant pressure cycle was among the earliest gas engines to be used in this country. So far as we are aware the numerous inherent advantages of operation on this cycle have never been fully realized owing in part to difficulties which were encountered in the early engines of this type. It is believed that most of these can be overcome by the use of modern methods and materials. On this account much interest should attach to experiments along this line. Because of its steam-engine-like characteristics the constant pressure engine is unusually well suited for vehicle propulsion. It remains to be seen whether certain difficulties which are involved in a development along this line can be overcome. If so, and if the engine proves to be as economical under practical operating conditions as engines of the constant volume type, it should see wide application for automotive propulsion.

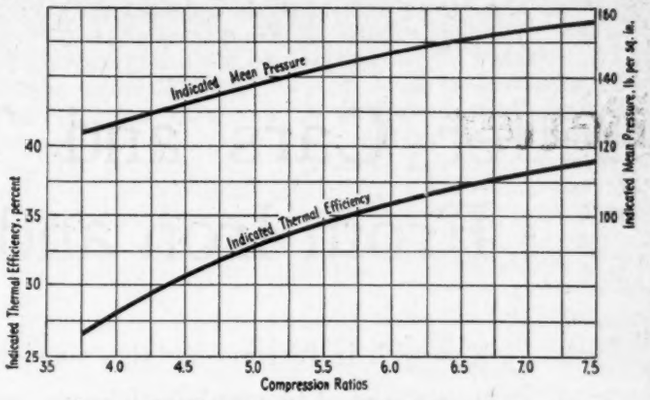


Fig. 4—Relation between compression ratio and indicated mean pressure and thermal efficiency

Steam Engine Developments

THE high torque, especially at starting and under heavy load conditions which the steam engine is capable of developing when used in connection with a well designed boiler, and its flexibility continue to make it an attractive subject for development work. Although its use involves certain drawbacks, it is, of course, capable of developing power on relatively low grade fuels without trouble from detonation and many other disadvantages of the internal combustion type. It is, therefore, not to be wondered at that work with it is progressing in several quarters looking to its use especially for heavy tractive work such as is involved in trucks and tractors. Much work is also going forward in the development of steam operated buses such as are already used extensively in England. Developments in the steam driven passenger car field are continuing, both among new and old manufacturers, but reliable data concerning the performance of the more promising of the vehicles recently constructed is lacking.

Research Work on Engine Performance

MUCH research work has been conducted during the past year into the performance of engines under various conditions of operation. Heat and frictional losses are being investigated in many quarters. Professor C. E. Lucke of Columbia University, is for example, making investigation into heat losses through engine walls in case of both water and air cooled types of cylinders, and much work in this direction has been done by the General Motors Research Laboratory. Tests involving a measurement of heat lost to the jacket water in truck engines are being made by the Autocar Co.

Ricardo in connection with his research work* had occasion to make a study of mechanical efficiency, the influence of cylinder size on engine performance, and of cylinder temperature on power output. He also determined the heat distribution in an engine using various fuels at various compression ratios, in addition to much other work along similar lines to which reference has already been made.

It will thus be seen that the subject of improved engine performance has not been overlooked in spite of the fact that much contemplated work along this line has necessarily been curtailed owing to the unsatisfactory business conditions of the past year.

*A series of Ricardo's reports were published last year in these columns under the heading Influence of Various Fuels on Engine Performance. A later report entitled Recent Research Work on the Internal Combustion Engine was presented by Ricardo before the Society of Automotive Engineers at its last annual meeting, and a summary thereof appeared in these columns, issue of Jan. 19, 1922. The report was published in full with appendices containing much useful data and discussion in the *Journal of the S. A. E.* for May, 1922.

Better Cars and Trucks May Result From Iron and Steel Research

Research in ferrous metals covers wide range. Automotive industry vitally concerned in results. Chrome molybdenum steels studied. High carbon steel brake drums developed. New facts determined in resistance-to-wear investigation. Further development in heat treatment likely.

By P. M. Heldt

PROBABLY in no line of industrial activity is research being carried on as extensively as in the iron and steel field. The ferrous metals not only have the most valuable mechanical properties but they are also very abundant, and on account of their cheapness, their high tensile strength, and their hardening and magnetic qualities they lend themselves excellently to a great variety of uses. The introduction of alloy steels during the latter part of the past century and of heat-treating processes has added greatly to the subjects calling for research. Much of the experimental work in connection with various methods of testing also is closely related to iron and steel, for, although hardness tests, shock tests, etc., are applicable to many other materials, they are used much more on ferrous materials than on any others.

Research on iron and steel is being carried on at industrial laboratories connected with the large steel works, at national metallurgical laboratories and at laboratories connected with universities and mining schools. Each of the great industrial countries has its technical organization of iron and steel metallurgists, of which the British Iron and Steel Institute is typical, at whose annual or semi-annual meetings many of the results of research work in this line are made public. The Society of Automotive Engineers has standardized steels for use in automobile construction, and recently the industries of several other countries have followed the lead, which might give the impression that a certain degree of stability must have been reached and that the chances for important advancements in metallurgical products and practices must have been greatly reduced, yet research in this line is being carried on more intensively than ever before. Only a small portion of this research work, of course, has a direct bearing on the automotive industry, but that part is very important. The development of alloy steels and of heat treatments is very closely bound up with this industry. The results of some recent research of interest to automotive producers are reviewed in the following.

New Tests in Fatigue of Metals

AT a meeting of the New England members of the American Society for Steel Treating and the Hartford Branch of the A. S. M. E. at the plant of the New Departure Mfg. Co. in Bristol, Conn., Prof. H. F. Moore of the University of Illinois gave some of the latest results of the research work on the fatigue of metals carried on at that institution with funds furnished by the Research Foundation and the General Electric Co. The interest of the General Electric Co. in the problem of fatigue is probably based on its work in the manufacture of steam turbines, and Prof. Moore mentioned the case of a turbine failure as a very impressive example illustrating the importance of the study of the fatigue problem.

When the problem was taken up, the first thing to do was to select or develop a suitable endurance machine. A slide was shown of the Upton-Lewis machine which is being used at Cornell University in work of this kind and is satisfactory under some conditions but has certain limitations. The machine now used at the University of Illinois is of a type which all experimenters on fatigue seem to come to in the end, Prof. Moore said. It is known as the Farmer rotating beam testing machine and consists of a base with two bearing pillars containing ball bearings in which the beam is supported. The middle section of the cylindrical beam is reduced in diameter and at both sides of this reduced section are mounted ball bearings from which, through an equalizing bar, the loading weights are supported. It was found that without a reduction in section at the center of the beam the beam would invariably fail at the inner edge of the stationary bearing, this being a point of stress concentration. This is not desirable, for one reason because it is difficult to accurately calculate the stress at this point due to any particular load.

An extended investigation was made with respect to the best form for the reduced section. At first the center portion was merely turned down to a smaller diameter.

the shoulders being rounded. The objection to this method was found to be that it is almost impossible to obtain a perfect joint or perfect continuity between the central cylindrical portion and the fillets. It was also found that nothing starts failure so easily as a sharp change in section. The form of the reduced portion of the cylindrical test beam is therefore made such that a longitudinal section of it is bounded by circular arcs of 9.85 in. radius. The stress in the beam at any section can be readily calculated from the loading weights and their position relative to the supports. The question then arose whether the stress so calculated was the actual stress. The results were checked up at the General Electric Co.'s Laboratory, which possesses one of Prof. Coker's optical stress measuring apparatus, and also by means of a very accurate extensometer, and the results in both cases checked to within 1 per cent.

It will be understood that in the tests the specimen is revolved by means of a driving shaft co-axial with the specimen, with pulley and universal coupling. The stress in the specimen is then reversed twice per revolution.

In the test it was found that up to a certain unit stress the strength of the metal in the specimen was not affected by fatigue, that is to say, with the maximum stress limited to these figures the load could be reversed indefinitely without failure occurring so far as could be determined. But beyond this limiting unit stress, which is called the endurance limit, the life or endurance of the specimen fell off with an increase in unit stress.

A considerable portion of the research work had to do with the exact nature of the failure under repeated reversal of stress, and what might be called animated micro-photographs of the specimen while approaching failure were shown. It was seen that under the reversal of stress slight cleavages occur near the outer surface where the tension is greatest and that these gradually increase until failure occurs. These cleavages are referred to as slip lines. At first there appears to be a very large number of these slip lines, but as the reversal of stress goes on some of the slip lines seem to develop faster than others.

The thought suggested itself that probably the endurance limit was identical with or had a close relation to the elastic limit. Prof. Moore said that there was no such thing as an elastic limit considered as an absolute measure of the limit of perfect elastic action. There were at least eight different definitions of this factor, he said, consequently no definite relation between it and the endurance limit could be established. On the other hand, it was found that there was a close correlation between the endurance limit and the ultimate strength, and also between the endurance limit and the Brinell hardness. Roughly speaking, 250 times the Brinell hardness was equal to the endurance limit. That the endurance limit should be proportional to the ultimate strength under tensile loads is not hard to understand when the way in which the failure under reversal of stress occurs is considered.

Prof. Moore said that results based upon the ordinary static tests of materials must be regarded in the nature of cartoons of the properties of these materials. They are based upon the assumption that metals were of homogeneous structure, and all micrographs showed that this was not the case. These tests brought out the outstanding characteristics, but left out many other features. Ductility, he said, was an insurance feature against occasional overloads. Most members of steel structures were loaded beyond their elastic limit in one point or another, but since this loading was not frequently repeated it had no effect on the safety of the members. Materials for members subjected to repeated stress should be as nearly uniform as possible.

Prof. Moore said that some years ago Mr. Stromeier, a British engineer, had suggested that the sliding of particles of the material over each other when subjected to reverse stresses generated heat, and that, consequently, impending failure of a test specimen would be indicated by a rise in temperature at the point where failure should occur. Accordingly, at the University of Illinois Experimental Station they had placed a thermocouple very close to the section of the specimen where the break would occur, directly against the steel, while the other joint of the dissimilar metals was located near one end of the test specimen and insulated from it by a layer of paper. A Leeds & Northrup galvanometer was inserted in circuit and differences in temperature as low as 0.003 deg. C. could be detected. Tests made by this method clearly showed the endurance limit with a fair degree of accuracy. The view was expressed that such a temperature measuring apparatus would prove useful in shortening the time required by the usual breakdown endurance tests.

Determining Resistance to Wear

J. A. BRINELL has developed a method for determining the resistance of metals to wear which is claimed to be an improvement on the methods of Felix Robin, Prof. A. Cary, Bauschinger, Aug. Roseval and Dr. F. Rogers. None of these methods has come into extensive use, probably because they are not practical.

Brinell's machine consists of a vertical disk 4 mm. thick and originally 100 mm. in diameter, of the softest, thoroughly annealed Martin steel. The disk is rotated at a speed of only 19 r.p.m. to prevent heating influencing the result. The test piece, which must have one flat side and at least one straight top edge, is pressed, by means of a holder, with the flat side against the top of the disk under a certain pressure. Over the point of contact between the disk and test piece is secured a glass funnel filled with pure quartz sand, from which a continuous stream of sand runs into the bevel space between the test piece and the disk. The disk turns between lateral guides so the sand cannot escape at the sides, and all of it becomes effective as an abrasive at the line of contact. The duration of the test and the pressure are so fixed for the different materials that the maximum depth of wear as a rule does not exceed 0.8 mm. For greater depths of wear the results become less accurate.

The depth of the segment worn into the test piece is measured by means of a depth gage or a micrometer. As a measure of the resistance to wear, N_w, Brinell takes 1000/A, where A represents the volume of wear in cu. mm. per millimeter width of disk. Brinell has compiled tables of values of A for segment depths of 0.01 to 2.7 mm. and disk diameters of 100 to 97.5 mm. The best material for the disk has been found to be annealed Swedish Martin steel with a carbon content of 0.010 per cent. It might be expected that the hardest materials would wear the longest, but that is by no means always the case. Resistance to wear depends not only upon the

hardness but also upon the elongation and probably also upon other qualities of the metal so far undetermined. Felix Robin, in a paper on The Wear of Steels, has shown that when a substance is being rubbed with an abrasive, the grains of abrasive first enter the material and cause a depression. The motion then converts this into a scratch or slot, whereby the displaced material is pushed aside. If the material is hard and has little elongation it becomes easily detached, whereas if it is soft and has high elongation it is not so easily detached. In the case of very hard steel with little elongation the resistance to wear is increased by the fact that the hardness prevents easy penetration, but this is counteracted by the easy detachability of the displaced particles. The relations are the exact opposite in vulcanized rubber, whose high elongation increases its resistance to wear while its softness increases it.

As accurate results are obtained only by keeping the depth of wear between 0.2 and 0.8 mm., it is necessary to use different pressures and continue the test for different lengths of time with different wear resistances. F. Robin has shown that the wear increases slightly with the velocity and materially with the pressure. Brinell made tests under conditions of varying pressure with both hardened and unhardened carbon steels, and also with alloy steels, and his results are summarized in the following table.

Wear in 1/100 Cu. Mm. per Mm. Disk Thickness

Grade of Steel	Unhardened Carbon Steel			Hardened Carbon Steel			Alloy Steel		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
No. 1010...	525	298	218	497	274	176	...	...	...
No. 1050...	468	240	166	348	218	166	...	...	...
No. 1130...	440	218	146	323	207	136	...	...	...
No. 4345...	...	...	...	...	...	...	400	240	166
No. 4337...	1,433	756	530	1,168	...	...	440	263	166
K	...	...	...	...	...	...	348	240	166
Total	1,433	756	530	1,168	699	478	1,188	743	498

Test No. 1—10 kg. pressure, 10 min. time.
Test No. 2—10 kg. pressure, 5 min. time.
Test No. 3—5 kg. pressure, 10 min. time.

It might have been expected that in test No. 2 the wear would have been twice as great as in test No. 1 as the time of the test was doubled. That this is not the case is due to the increase in contact surface as the test proceeds. Brinell suggests that the disadvantage due to the fact that the wearing surface at the beginning of the test = 0 may be overcome by causing the wear to take place on the end surface of a small test rod which has previously been given the proper radius by means of an emery wheel to fit the disk immediately. But such a test would be less convenient and more expensive.

It would be desirable to be able to place all materials in a series, if for all the same pressure were used and the test were discontinued as soon as the standard depth of wear had been reached. Brinell is going to conduct research along this line. In that case the depth of wear would be eliminated and only the wear distance would remain, that is, the distance covered by the disk circumference with any material in producing the standard depth of wear. The requirements made of a standard method of measuring wear are as follows:

1. It must give reliable results, be simple and be readily adaptable to practical conditions.
2. The preparation of the test pieces must be simple.
3. The method must be applicable to both hard and soft materials.

In this last respect Brinell considers his method unobjectionable. If it were possible to automatically indicate the time required to wear to a certain depth a simple method would be available.

Dependence of Brinell Hardness Upon Mass

In the tables of physical characteristics of steels issued by the S. A. E. it is stated that the figures given may be expected to be obtained from rolled bars up to 1½ in. diameter or square, whereby cognizance is taken of the fact that the effect of heat treatment varies with the mass of metal treated and particularly with the maximum distance of any portion from the surface of the treated piece. E. J. Janitzky, metallurgical engineer, Illinois Steel Co., has been investigating the effect of mass particularly upon the hardness test results and has discussed the matter in two papers presented to the American Society for Steel Treating.

As the section of the piece quenched is reduced, a greater Brinell hardness will be obtained, down to the diameter where the whole section on quenching attains a perfect martensitic structure. With this and all smaller sections the maximum hardness possible with the particular steel and quenching conditions is attained. With alloy steels of the structural type this section has a diameter somewhere between ½ and 1 in.

In the first paper referred to a formula is given for the Brinell hardness of any round section, based upon the normalized Brinell hardness of the steel, the diameter of the section and various constants. This applied to a 0.45 per cent carbon steel. The second paper, presented to the Sectional Meeting held at New York in March, had for its object to show that the same general formula could be applied to structural alloy steel and that the formula also holds good for points on cross sections of round parts half way between the center and circumference. The discussion given by Mr. Janitzky is not based upon the mean of a series of tests but upon a single test by a single experimenter and no doubt greater accuracy in the constants appearing in the formula could be attained if the experiments were repeated by others.

Brake Drums of High Carbon Steel

BRAKE drums, as well as other drawn parts of sheet steel, are usually made of low carbon or soft steel, because this steel is naturally more ductile than steel with a higher carbon content and is, therefore, not so easily injured in the cold working process. However, low carbon steel has certain disadvantages for this purpose, and for cars in which the brakes are subjected to severe usage, such as racing cars, the brake drums are often made from forgings of a higher carbon steel. Recently the Midvale Steel and Ordnance Co. has been making experiments in the manufacture of high carbon steel brake drums, the carbon content running from 0.35 to 0.90 per cent. The concern claims to have successfully produced drums that are now in operation on a number of cars and are giving very satisfactory results, a fact that should interest automobile engineers.

The development of high carbon steel brake drums is particularly interesting because a good many cars are being redesigned with a view to the use of transmission brakes, and the service is considerably more severe in the case of transmission brakes than in that of rear wheel brakes, as regards wear and grooving of the brake drum,

with consequent reduction in the life of lining. In installations of this kind the high carbon steel brake drum is said to be very desirable because it resists grooving and retains its polish, this being due to the greater hardness of the high carbon steel. The final result is an increase in the life of the brake lining.

Thermo-Electric Phenomena for Identifying Certain Steels

BY means of the Brinell test it is possible to identify carbon steels with sufficient accuracy for practical purposes, but this is not possible in the case of alloy steels. This led H. Le Chatelier to look for a method of classifying steels in a different order from that of hardness which would still be applicable to individual pieces. A note on Chatelier's results was presented to the French Academy of Sciences by M. Gallibourg some time ago.

The arrangement shown in Fig. 1, based on the use of the contact electromotive force, meets these requirements. A mercury bath is heated to 120 deg. C. by an electric heating element of nichrome. A wire of electrolytic iron inserted into the mercury is connected to one terminal of a milli-voltmeter. The other terminal is connected to a metal clamp cooled by water circulation, which holds the sample. The sample is held by the clamp at one end and is brought in contact with the mercury at the other. At the end of 4 or 5 minutes the hand of the millivoltmeter remains stationary. The only object of the mercury is to close the circuit, by insuring a perfect electrical and thermal connection between the wire of standard metal and the sample.

A large number of tests were made to determine the electromotive force produced under these conditions by various ordinary and alloy steels for temperatures between 20 and 320 deg. C. For the highest temperatures the mercury is replaced by lead. The tests were made with the set-up shown in Fig. 2.

In the illustration the reactance coil with its movable core is incorporated in the circuit of the nichrome heater and serves to regulate the flow of current through same; it has otherwise nothing to do with the test.

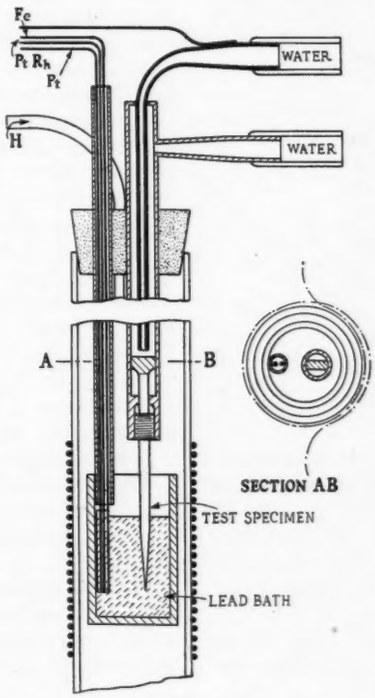


Fig. 1

Results Obtained With Nickel Steel

No.	C.	Mn.	Si.	Ni.	Thermo-electromotive force 120 deg. C.	200 deg. C.	300 deg. C.
1	0.08	0.34	0.13	2.15	0.8	1.25	1.70
2	0.12	0.01	0.05	5.23	1.8	2.80	3.85
3	0.12	0.12	0.05	7.13	2.1	3.40	4.80

Hardening has little influence on the form of the thermal electromotive force curve, as shown by the following tabulation:

	Annealed E.M.F. 120 deg.	300 deg.	Hardened E.M.F. 120 deg.	300 deg.
Carbon steel	0.50	0.95	0.55	1.15
Chrome-tungsten steel	0.25	0.25	0.25	0.35

The differences in the electromotive forces obtained with the different steels are sufficient in order that at the temperature chosen for the tests (120 deg.) the measurement of the electromotive force under the conditions indicated permits of classing both carbon and alloy steels in a different order from that obtained by the Brinell test, thus giving a second equation (the first being furnished by the hardness), to determine the character of a steel which cannot be subjected to an analysis.

In Fig. 3 the results obtained in the thermo-electric tests with nickel steels are shown graphically, the numbers of the curves corresponding to the numbers of the specimens in the table at the top of this column. It will be seen that the e.m.fs. increase with the nickel content. This is exactly what would be expected, as the thermo-electromotive force is taken relative to electrolytic or pure iron, and, nickel being the chief alloying component, the less the nickel content the more the composition approaches the standard metal. If both the standard wire and the sample have the same composition no electromotive force is set up.

Fig. 2

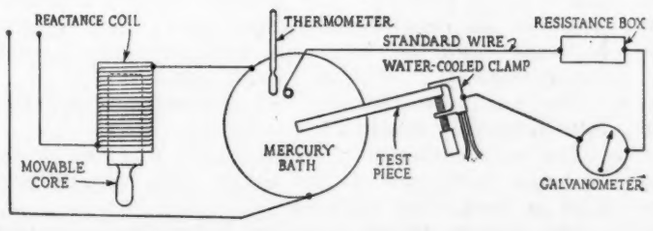
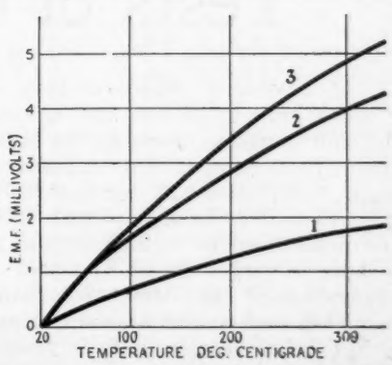
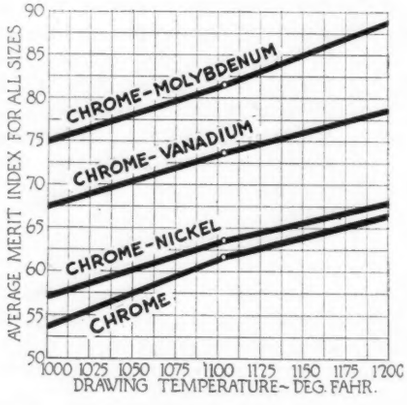


Fig. 3



Chrome Molybdenum Steels

MOLYBDENUM alloy steel is the latest structural steel to be introduced in automobile manufacture, being essentially a war product and in a certain measure, at least, the result of scarcity of other alloying elements during the war period. Naturally, a great deal of research work in connection with this new steel has been done during the past few years, partly by the steel makers and partly by users. At the last annual meeting of the S. A. E., a paper on "Chrome Molybdenum Steel Applications from the Consumer's Standpoint" was presented by C. N. Dawe, metallurgical engineer of the Studebaker Corporation. This concern is using chrome-molybdenum steel for rear axle shafts, transmission gears and shafts, steering knuckles and pins, ring gears and drive pinions, and already at that time had received delivery of upward of 2000 tons of this steel. It was found that for water-quenched parts the following composition gave good results: Carbon, above 0.23 and below 0.30 per cent; chromium, 0.70-0.90 per cent; molybdenum, 0.30-0.40 per cent.



Mr. Dawe points out that what consumers are specially interested in is the lowest quenching temperature which will give the maximum physical properties, and in comparative tests quenching temperatures of 1550-1650 deg. Fahr. were used for chrome vanadium, chrome molybdenum and chrome steels, and 1475 to 1575 deg. Fahr. for nickel steels. In making a comparison of the different steels, Mr. Dawe made use of a merit index given in a paper by John D. Cutter before the American Society for Steel Treating. This index is based on the tensile strength, elastic limit, elongation and reduction of area, and therefore takes in practically all the important physical properties.

In the tables given in the paper, containing the results of approximately 400 tests, this index is generally greater for chrome molybdenum steel than for any of the other alloy steels. With reference to the action of chrome molybdenum steel in various stages of production, Mr. Dawe states that it forges very satisfactorily, having the particular advantage that the scale formed breaks away from the forgings very easily. With proper composition and with sizes within ordinary limits it cold-shears as readily as the harder grades of alloy steels. It responds very readily to the heat treating operations, the percentage of forgings falling outside the required Brinell hardness being very small.

Chrome molybdenum steel has also been used for case hardened parts by the Studebaker Co., and some peculiar characteristics of the steel were noted in this connection. To get the best results, the piece to be heat treated had to be subjected to prolonged heating above the critical temperature of the core to bring about the proper condition for quenching, and the lower heat for hardening had to be applied as quickly as possible to prevent the core from being subjected to lengthy heating at the lower temperature.

To obtain the best possible results with the case-hardened parts, it was necessary, therefore, to quench from the carbonizing box into oil and follow this by the regular double heat-treatment and a final draw at 375 to 400 deg. Fahr., timing each operation as carefully as possible. There are two particular advantages that should be noted, however, in that chrome-molybdenum steel will take on a given case-depth in 10 per cent less time than chrome-nickel steel; also, there will be a resultant average increase in Shore hardness of from 5 to 7 points.

The Studebaker Corporation, however, has given up the use of case-hardening chrome molybdenum steels for highly stressed parts and Mr. Dawe concludes that chrome nickel steel is still the best commercial case-hardening steel for important parts, though chrome molybdenum steel is a serious contender. He believes that for parts where hardness alone is an important factor chrome molybdenum steel is entirely satisfactory.

Tests of Centrifugally Cast Steel

AT the Bureau of Standards tests have been made of hollow cylindrical steel castings with from ½ in. to 8½ in. wall thickness, made by the Millspaugh centrifugal process. Their composition ranged from two low-carbon steels, C = 0.17 and 0.23 per cent, to three nickel steels ranging in carbon from C = 0.33, 0.46 to 0.66 per cent, and in nickel from Ni = 2.69, 2.35 to 2.92 per cent. The wide range in carbon should be noted.

Segregation of the elements carbon, phosphorus, sulphur, nickel and copper appears to exist to a slight extent, but only radially, and is most marked next the inner surface in a narrow zone of about one-sixteenth inch depth. Manganese and silicon do not segregate in this type of casting. The greatest carbon segregation was 0.09 per cent in nickel steel (C = 0.66, Ni = 2.92 per cent) and the least was 0.02 per cent in another nickel steel (C = 0.33, Ni = 2.69 per cent).

The hardness (Brinell and scleroscope) practically follows the segregation.

The only evidence of unsoundness was the presence of small blowholes in the inner zone, usually within 1/16 in. below the surface.

The density across a section is practically constant; that is, to within 0.004 in 7.836.

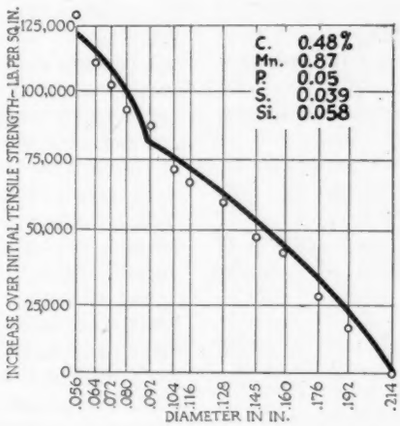
The mechanical properties show, in general, somewhat greater strength, elastic limit, and resistance to shock, but less ductility, in the tangential than in the longitudinal direction.

The internal stresses developed in the castings by this centrifugal process of manufacture, as determined from measurements on three rings from each of two castings. show values of the order of the elastic limit with the outer zones in compression.

The effect of heat treatment in improving the physical properties of the castings is very marked. The results suggest that the properties of such castings suitably treated may rival those of forgings of the same chemical composition.

Increase in Tensile Strength Due to Cold Drawing

IT is generally known that the strength of steel is increased by cold working, and especially by cold drawing. An attempt to establish the laws of increase in tensile strength in relation to the flow or deformation of the material in cold drawing has been made by E. J. Janitzky, metallurgical engineer of the Illinois Steel Co., who published an article on the subject in a recent issue of *Iron Age*. Janitzky bases his argument on the experimental work of Goerens (1911), Percy Longmuir (1913) and J. F. Tinsley (1914). All agree that cold drawing increases the tensile strength and reduces the elongation and contraction of area. Goerens drew the general conclusion that the tensile strength increases in proportion to the deformation of the metal; Longmuir stated that in no case was the increase in tensile strength exactly proportional to the amount of flow. Tinsley derived a formula according to which the increase in the tensile strength is equal to 1000 lb. p. sq. in. times the proportion of the decrease in section to the original section. Janitzky, by analyzing the experimental data published, came to the conclusion that this formula does not hold throughout the possible range of reduction. Curves are plotted showing the diameter of the wire as ordinates and the increase in tensile strength as abscissas. At a reduction of 90 per cent in a 0.10 per cent carbon steel there appears to be a break in the curve, and beyond this point the formula gives much too low values. A new curve starting from the breaking point also has a parabolic form, the same as the original portion of the curve, but is much steeper in slope. As the drawing is continued additional breaking points are found, the curve making a sudden change in direction at each of these points.



Janitzky reaches the conclusion that each portion of the complete curve can be determined by means of a formula very similar to that above stated, but using only one-half the proportional reduction in area and using the tensile strength and the area of the breaking point as a basis. Of course, instead of using one-half the proportional reduction and the constant 1000 he might just as well have used the proportional reduction and the constant 500. This leads to the following general equation for the strength after drawing:

$$T = \frac{A_n - a}{A_n} \times 100 \times 1000 + T_n,$$

where A_n is the area and T_n the tensile strength corresponding to any of the breaking points a the area after drawing and T the tensile strength after drawing.

The carbon content seems to influence the increase in tensile strength as drawing progresses only to the extent that the higher the carbon content the earlier will the first breaking point in the curve occur. Thus with a 0.10 per cent carbon steel the first breaking point occurs at a reduction of 90 per cent; with a 0.50 per cent carbon, at a reduction of 80 per cent and with a 70 per cent carbon steel at a reduction of 70 per cent. From the initial point to the first breaking point carbon has no influence on the rate of increase of tensile strength; beyond the first breaking point the increase is proportional to the reduction from the breaking point used as a base, the constant 500 being used for low and medium carbon steel and 1000 for high carbon steel.

The accompanying curve shows observed and calculated increases in tensile strength for a 0.48 per cent carbon steel. The close agreement between the curve and observed values will be noted.

Uranium as a Steel Alloying Element

URANIUM belongs to the group of metals that comprises tungsten, molybdenum and vanadium, which play such an important part as steel alloying elements. The ores of uranium are found in only a few parts of the world, including Joachimstal, Bohemia, Johanngeorgenstadt, Saxony, Paradox Valley and other places in Colorado and in Utah.

The separation of uranium from its ores is a costly and complicated process because of the refractory character of these ores. But the ores are seldom treated only for their uranium content. Indeed, this is more often a by-product of the recovery of radium or vanadium, or both, and thus the cost of treatment is shared between two or more products.

Uranium imparts remarkable physical properties to steels and alloys. When added to steels, it does not need to be augmented or intensified by the addition of other constituents, as is the case with some other steel-alloying elements. It increases the hardness and hardening power of steels by reason of its ability to emphasize the characteristics of cementite; the hardness imparted thereby is not accompanied by the brittleness that is character-

istic of other carbide-forming alloys. As a substitute for tungsten in special alloy steels it is claimed that a small proportion of uranium is equivalent to a relatively large proportion of tungsten.

Uranium steels are pre-eminently adapted for uses necessitating a low drawing temperature in that they possess under these conditions a remarkable combination of hardness, strength and durability.

The effect of the addition of small amounts of uranium on the physical properties of alloy steels is shown by the results (see Table I) reported by H. S. Foote in a recent issue of *Chemical and Metallurgical Engineering*, on different classes of alloy steel and compared on a like basis of ductility.

Table I.

Composition.	Elastic Limit	Tensile Strength	Elongation per cent.	Reduction in Area.
C, 0.32; Ur, 0.22	154,800	162,000	15.5	59.3
C, 0.30; Ni, 0.22	111,000	124,000	15.5	53.0
C, 0.31; Cr, 0.39; Va, 0.16	146,200	162,700	15.0	57.0
C, 0.28; Cr, 0.85; Mo, 0.37	154,000	165,000	15.0	58.3

These figures show that a small percentage of uranium increases the elastic limit and tensile strength to a point comparable with those of more complex alloy steels.

But while uranium alone in carbon steels produces results as shown, it also intensifies the desirable properties in the more complex steels. Foote supplies data of tests on uranium-nickel steels of the following percentage compositions which illustrate this fact: (*a*) C, 0.39; Ur, 0.22; Mn, 0.60; Si, 0.20; Ni, 3; quenched in oil from 1425 deg. F. (*b*) C, 0.45; Ur, 0.29; Mn, 0.48; Si, 0.53; Ni, 3; quenched in oil from 1475 deg. F. These tests are recorded in Table II, and it is interesting to note that the combination of small amounts of uranium with nickel produces a steel in which the desirable effects of both alloying elements are magnified. Many other examples might be supplied, but those given show that in alloy steels containing a little uranium, there is a material of extraordinary physical properties which for certain special purposes cannot be replaced by any other material equally suitable.

Table II.

	Elastic Limit.	Tensile Strength.	Elongation per cent.	Reduction in Area.	Brinell Hardness.	Drawing Temperature.
(*a*)	206,400	248,600	13.0	47.7	512	400
(*b*)	244,500	290,100	10.0	29.1	555	—
(*a*)	199,200	231,100	13.5	51.1	477	500
(*b*)	238,900	271,100	10.5	35.5	512	—
(*a*)	183,300	202,100	13.5	54.1	418	600
(*b*)	212.000	228,000	11.0	39.0	464	—
(*a*)	164,100	177,200	15.0	56.0	387	700
(*b*)	185,000	198,200	12.0	45.0	415	—

(*a*) Charpy test, 156 ft.-lb. per square inch.
(*b*) Charpy test, 73.8 ft.-lb. per square inch.
(*a*) Alternating impact, 934 blows (⅜ in. throw).
(*b*) Alternating impact, 900 blows (⅜ in. throw.

As a constituent of high-speed tool steels, uranium has been found to be of great value. A metallographic study of high-speed steels indicates that the uranium tends to promote the formation of complex carbides upon which are dependent the cutting efficiency and the property of "red hardness." A complex uranium carbide is apparently more soluble in gamma iron than the carbides ordinarily found in high-speed tool steels, and it is reasonable to infer that uranium exerts an important influence on the property of "secondary hardness."

While the valuable properties of uranium steels have come to be widely appreciated, the relative scarcity of the ores of uranium limits the quantity of such steels that can be produced, and makes it improbable that the metal will ever be cheap enough to compete with other more abundant steel-alloying elements.

Effect of Uranium on Steel

IN the *Revue de Metallurgie* for June, 1920, E. Polushkin reports researches on uranium steel made in 1918 for an American company. He draws the following conclusions:

Uranium does not in the least affect the position of A_{c_1}, except when the uranium content is very high, about 7 per cent, when all critical points are suppressed. A_{r_1} is not noticeably lowered, except when the uranium content is above 2 per cent.

In steels with medium carbon content, 0.25-0.45 per cent, uranium raises the elastic limit and tensile strength, without affecting the ductility, or it may even raise the ductility, too. In steels with 0.60 per cent of carbon or more, uranium raises the tensile strength and elastic limit, but this steel has considerably less ductility. Uranium increases the hardness of steels. A melt of steel with uranium and steel gave very good results, the product being more ductile than ordinary nickel steel and chrome vanadium steel. Other melts, however, showed absolutely no favorable effect of uranium.

The comparative value of the good effects of the uranium outlined in the foregoing could not be determined exactly, by reason of the special conditions of fabrication and heat treatment, but in no case were any remarkable results obtained which could not be obtained with any other alloying elements. Uranium has absolutely no effect on the shock resistance or resistance to alternating stress.

Influence of Phosphorus on Low Carbon Steels

OPEN hearth low carbon steels are often used in the manufacture of products which require severe cold working in their fabrication. The Bureau of Standards therefore undertook an investigation to throw more light on the effect of different phosphorus contents upon the properties of such steels. No clear relationship could be established between the phosphorus content, varying between the limits 0.008 and 0.115 per cent (which marks the usual limits in plain carbon steels) and the microstructure and hardness as developed in two series of specimens, one of basic open hearth steel and the other of acid open hearth steel, by a series of different heat treatments, because of the marked irregularity in the distribution and grain size of the ferrite and pearlite grains found present in many of the specimens. This irregularity was traced, by means of the micro-structure as developed by etching, to the non-uniform distribution of the phosphorus. A cellularlike structure formed in conjunction with the micro-structure normal to these steels was studied and relationship between this unusual structure and the phosphorus distribution established.

Chromium Magnet Steels

OWING to the scarcity of tungsten in Germany during the war and the great demand for tungsten tool steels, it was found necessary to look for a substitute for the ordinary magnet steel which is a tungsten alloy steel. The Physikalisch-Technische Reichsanstalt then conducted a series of researches on the magnetic qualities of chromium steel for which samples in the form of rods of 6 mm. diameter and 22 cm. long were furnished by the Krupp Works. The results of this research were in the first place circulated confidentially. Recently this research work has been completed and a report on it was published by E. Grumlich in *Stahl und Eisen* of Jan. 12 and 19, 1922.

Samples with 3, 6 and 9 per cent of chromium were furnished by Krupps, and in the way of impurities these steels contained 0.03 per cent of silicon, 0.15 per cent of manganese and 0.08 per cent of copper. In the magnetic tests a maximum field strength of H=300 was worked with, and the remanence R and coercive force K for different quenching temperatures, as well as the product KR were determined. KR is a measure of the value of the steel for permanent magnets. It was found that, owing to the low value of this product, alloys with 1 and 9 per cent of chromium cannot be considered for use as magnet steel. With small chromium content the permanence of the magnets is not great, and these alloys are of little value for this reason.

With alloys of 2 to 6 per cent of chromium, remanence decreases with increasing hardening temperature, whereas the coercive force increases, at first rather fast and at higher temperatures more slowly. With increasing carbon content, the coercive force at first increases more rapidly than the remanence decreases, at least up to 1.1 per cent of carbon, so that the product RK first increases and then decreases with increasing hardening temperature and carbon content.

In general, with any particular carbon content the coercive force increases with the chromium content, at least up to 6 per cent chromium, the increase being more rapid with low than with high carbon. The remanence, on the other hand, generally shows a maximum value for as low as 3 per cent of chromium. The safest guide is again the RK value, which attains a maximum for both 850 and 900 deg. C, quenching temperature with about 1 per cent carbon and 3 to 5 per cent chromium, which seem to be the most promising alloys.

Oil quenching gave materially better results than water quenching, especially as regards the remanence. The comparison with tungsten steels in one of the tables herewith is based on the results obtained from samples submitted for test to the Reichsanstalt by different concerns. These therefore are representative of tungsten magnet steels used in practice. Oil-quenched chromium steels are somewhat better than tungsten steels.

The permanence of the magnets was tested by subjecting them to cyclic heating to 100 deg. C., to mechanical shock by dropping them from a height of 2.5 meters and to aging for successive periods aggregating one year. The loss of remanence through six cyclic heatings to 100 deg. C. was 3.42 per cent for steel with 1.04 per cent chromium, but only 1.15 per cent for steel with 8.05 per cent chromium.

As regards quenching temperatures, the loss of remanence was less for 850 and 900 deg. C. than for 800 and 950 deg. Loss of remanence through shock depends less on the chromium than on the carbon content. Loss with time was very slight (less than ½ per cent a year) and seems to decrease as the carbon content increases.

Table I—Influence of Hardening Temperature

Comp.		Remanence R			Coercive Force			Product RK		
Ch%	C%	R_{800}	R_{850}	R_{900}	K_{800}	K_{850}	K_{900}	$KR \times 10^{-3}_{800}$	KR_{850}	KR_{900}
2.85	.88	11280	10900	9500	49.7	57.4	**55.3**	561	626	526
2.90	1.12	10630	10380	8560	56.1	59.2	63.1	596	615	540
5.84	1.13	....	9920	9200	49.3	64.6	72.5	...	641	666

Table II—Influence of Carbon Content

C%	Remanence R		Coercive Force K		RK	
	R_{850}	R_{900}	K_{850}	K_{900}	$RK \times 10^{-3}_{850}$	$RK \times 10^{-3}_{900}$
0.20	8660	8560	36.6	36.2	317	310
0.68	9500	9300	50.4	55.5	479	519
0.88	10060	10000	51.5	56.4	518	564
1.13	9920	9200	64.6	72.5	641	666
1.63	....	8040	....	60.2	...	484
1.82	....	7030	....	67.7	...	476

Table III—Comparison of Oil and Water-Hardened Chromium and Tungsten Steels

Chromium Steel Magnets											Tungsten		
Ch %	C %	Hard. Temp.	Rem. R	Coerc. Force K	RK $\times 10^{-3}$	Ch %	C %	Rem. R	Coerc. Force K	RK $\times 10^{-3}$	Rem. R	Coerc. Force K	RK $\times 10^{-3}$
		Quenched in Water.					Oil-Quenched				10200	58.1	593
2.85	0.88	850	10900	57.4	626	1.93	0.81	12660	56.8	720	9700	61.5	596
2.90	1.12	850	10380	59.2	615	2.97	1.12	10910	60.7	662	10250	63.0	646
6.24	1.14	850	9920	64.6	641	6.24	1.14	12270	66.3	814	10880	62.3	679
6.24	1.14	900	9200	72.5	666	....	....	.....	....	...	10880	66.4	723
Aver.	....	...	10100	63.4	637	....	....	11950	61.3	732	10380	62.3	647

Light Metal Research Will Affect Future Car and Truck Design

New all-aluminum car embodies results of aluminum research work. Rosenhain's studies determine best alloy for aluminum pistons. Germans experiment with light alloys in high speed engines. Progress made in forging aluminum parts. Aluminum solders developed more highly.

ECONOMY of operation is one of the chief aims of modern car and truck design. Low fuel consumption affects this factor strongly. Consequently, attempts to further reduce vehicle weight will probably continue.

Thus, the research work which is being carried on by various organizations in connection with the lighter metals probably reflects future design possibilities to a greater extent than does any other research as far removed from practice.

America, England, France and Germany are all playing their part in this important work. The accompanying article outlines briefly the various activities which are being conducted and tells something about the results expected or already obtained.

It gives the first public detailed information about the new all-aluminum car that has been developed experimentally in this country, and tells many other facts of interest to you.

ALUMINUM has been used for machinery casings almost from the beginning of the automobile industry, and it gradually came into use also for a number of minor parts not subjected to any severe stresses. The application of the light metal in this line of engineering was greatly extended when aluminum pistons were introduced, about 1914. Later came the aluminum engine, as exemplified in the Hispano-Suiza aircraft engine, and the Marmon, Napier, Austro-Daimler and Szawe automobile engines. A still more recent development is the aluminum connecting rod, which is made from a special forgable aluminum alloy named duralumin, and at the present time there is under development in this country a design of car in which all parts that can conceivably be made of light metal or alloy are made of aluminum alloy.

Aluminum in automobile parts has its drawbacks as well as its advantages, and both the aluminum piston and the aluminum cylinder block were discarded by several manufacturers who had adopted them. One failure, however, does not establish impracticability. In this case it tended to show that the aluminum piston and the aluminum cylinder had not been developed to a sufficiently high degree to meet the most exacting requirements of the automobile field. The aluminum interests were not discouraged by these temporary setbacks, but continued their research with rather encouraging results.

The practical results of the experiments carried on by the Aluminum Manufacturers, Inc., are nearly all embodied in the all-aluminum car which they may shortly market. It is expected that twelve more of these aluminum cars will be made and tested out exhaustively and that the car will then be put in production. The chassis weighs 1550 lb., which is claimed to be 1000 lb. lighter than a chassis of corresponding wheelbase made in the customary way with steel channel frame members, etc. The frame members, frame cross-members, front axle, rear axle housing, brake drum, all of the exterior fittings, such as running boards, etc., are made of aluminum. There are no splash aprons, the frame acting as such. The steering gear has an aluminum housing, and the engine is practically an all-aluminum unit with steel and iron employed only in the wearing parts. The cylinder blocks are aluminum with cast iron sleeves shrunk into place. In the original design the camshaft bearings were directly in the aluminum block, but undue wear developed at this point, and, in the new cars about to be made up, bushings will be used for the camshaft bearings.

The aluminum frame side rails used in this car are made up of three castings welded together. The axle housing is a casting and so is the front axle. The connecting rods and various fittings throughout the car are forgings.

Aluminum connecting rods have proved very successful in this car as well as in others. Several engines made by the Continental Motors Corp. have been fitted with them on trial. Many of the seven-passenger cars made by a prominent Cleveland concern now have aluminum connecting rods in their engines, and the manufacturer of a well-known air-cooled car is said to be another convert to this type of rod. Aluminum connecting rods are under test by quite a number of manufacturers and apparently are giving good results in every instance. But the change from steel to aluminum in this vital, highly stressed part marks such a radical step that many engineers hesitate to make it until the test engines have been in operation for a long period of time. Some are even concerned that, in regular production, the rods might not show the same high physical qualities as the test rods, as these qualities in aluminum are apt to be dependent upon careful manipulation in forging and upon accurate heat treatment, which

calls for the employment of high-class labor.

In connection with the manufacture of aluminum parts it is necessary to develop an entirely new technique, as the tools which are suitable for steel, bronze and iron parts are far from satisfactory for this purpose. With aluminum the cutting speeds should be almost half way between what is used for wood and steel respectively. No manufacturers at the present time are making tools suitable for this kind of work.

One of the reasons why the aluminum car is considered commercially practicable is the fact that all of the parts can be machined at such a rapid rate that a plant of a given size will turn out a far greater number of aluminum than of steel parts. Cutting speeds of 1000 ft. per minute are very practical with aluminum. These high cutting speeds reduce the cost of manufacture, and, although there is $200 worth more material in a chassis than in a corresponding size steel chassis, the manufacturing cost need not be more than $40 or $50 higher with a moderate production, and would be about equal with large production.

Probably the next development in connection with the application of light alloys in automobiles will be the use of magnesium. Several companies have been organized in this country for the commercial exploitation of metallic magnesium and considerable research work is under way, but most of it is as yet only in its early stages.

Research for Best Alloy for Pistons

AN investigation to determine the most suitable alloys of aluminum for internal combustion engine pistons was made at the National Physical Laboratory, England, during the war and the years following it, and the results of this research are embodied in the Eleventh Report of the Alloys Research Committee of the Institution of Mechanical Engineers, of which Walter Rosenhain, Sidney L. Archbutt and D. Hanson are the authors. This report was published in August, 1921, and embodies the results of research extending over a period of more than eight years.

It was found that for pistons, alloys containing a high percentage of zinc are not suitable, because of the rapid falling off in strength of such alloys at high temperatures. This rules out both the binary aluminum-zinc alloys and the ternary aluminum-copper-zinc alloys with a high zinc content. As an illustration of this property, it may be mentioned that aluminum-zinc alloys with either 12 or 14 per cent of zinc show a decrease in tensile strength from ten tons per sq. in. at 0 deg. C. to a little over three tons at 350 deg. C. As regards aluminum-copper alloys, it is an interesting fact that between 200 and 250 deg. C., all of the alloys with from 6 to 14 per cent of copper have substantially the same strength, but above 250 deg. the 12 and 14 per cent alloys are somewhat better than the others.

It had long been known that the addition of manganese has a tendency to stiffen materials at high temperatures, and manganese was therefore added in small quantities in order to study its effect on copper-aluminum alloys. With 12 and 14 per cent alloys an addition of 1 per cent manganese caused the tensile strength to increase up to 250 deg. C. From this temperature up the tensile strength decreased, but at 350 deg. it was still much better than without the manganese, especially with the higher copper content.

An exploration was undertaken with both smaller and larger manganese contents, but a 1 per cent content was found to give the most satisfactory results. It appeared that an alloy containing 14 per cent of copper and 1 per cent of manganese could not be produced in the foundry as readily as other well-known aluminum alloys, and alloys with iron, molybdenum, tungsten, chromium and vanadium were explored, these elements being substituted for the manganese. In this connection it was kept in mind that other properties besides high tensile strength at high temperatures, such as high thermal conductivity, are also desirable. However, in most cases these additions rendered the alloy very brittle. It was also found that in some instances the high melting point components on solidification tended to form a skeleton from which the more fusible alloy drained away, leaving a porous casting. The addition of iron to the usual aluminum alloys was found not to produce any improvement at high temperatures and increased the foundry difficulties.

The next step was to experiment with nickel additions to aluminum-copper alloys and with magnesium additions to these. It was found that in the presence of both nickel and magnesium the copper content could be safely reduced, which resulted in decreasing the specific gravity of the alloy and increasing its thermal conductivity.

What is referred to as Y alloy was finally developed as the most suitable for piston material. It contains 4 per cent of copper, 2 per cent of nickel and 1½ per cent of magnesium. At moderate temperatures this alloy is enormously better than the 14 per cent copper binary alloy as regards tensile strength, but at 350 deg. C. (662 deg. F.) the tensile strength of the two approach each other. At 0 deg. C. the quarternary alloy mentioned has a tensile strength of about 13.4 tons, as compared with 10 tons for the binary alloy, and at 200 deg. the strengths are still further apart.

An interesting and important feature of both sand and chill castings of the aluminum-copper-nickel-magnesium alloy is that test specimens show a really appreciable amount of elongation, and at high temperatures, above 300 deg., this increases very rapidly. This led the authors to try forging and rolling this material. A nickel content of 2 per cent and magnesium content of 1½ per cent was found to be the best by explorational experiments.

In preparing the Y alloy certain precautions are necessary. The magnesium must be added just before pouring, and it is best to add it in the form of fairly large pieces of pure metal which should be immediately pushed below the surface of the aluminum, so they can dissolve without coming in contact with the air. If added at an earlier stage of the melting operation, a considerable proportion of the magnesium is likely to be lost. Nickel is added as follows: A hardener or rich nickel alloy (about 20 per cent) is first prepared, and this is added in the proper proportion to the molten aluminum.

Castings of this alloy are likely to show a large number of so-called pinholes, but tests have shown that these do not materially weaken the material. Measurements of the contraction on cooling show that there is no great difference between the different alloys and that the more complicated alloys show less contraction than the binary zinc-aluminum alloys. Thermal conductivity is an important feature of an alloy intended for internal combustion engine pistons, and in this respect the Y alloy gave the following results:

Coefficients of Thermal Conductivity, Y Alloy

(Sand Castings)

As Cast	At 100 deg. C.	0.35
	At 300 deg. C.	0.37

Chill Cast

As Cast	At 100 deg. C.	0.37
	At 300 deg. C.	0.40
Annealed at 450 deg. C.	At 100 deg. C.	0.40
	At 300 deg. C.	0.41

This compares with the following values for cast iron (sand castings):

Coefficients of Thermal Conductivity of Cast Iron (Sand Castings)

As cast	At 100 deg. C.	0.102
	At 300 deg. C.	0.099
Annealed at 450 deg. C.	At 100 deg. C.	0.121
	At 300 deg. C.	0.113

The cast iron on which the determinations were made, as cast had the following composition: Graphite, 2.64; combined carbon, 0.85; silicon, 1.84; sulphur, 0.078; phosphorus, 1.09; manganese, 0.82. After annealing the composition was as follows: Graphite, 3.34; combined carbon, 0.15; silicon, 1.94; sulphur, 0.070; phosphorus, 1.09; manganese, 0.85.

It was proved that material improvement in the physical characteristics of the castings could be obtained by suitable heat treatment of aluminum alloys, especially those containing magnesium. With chill bars of alloy containing 2, 3, 4 and 4½ per cent of copper, it was found that annealing for three days at between 450 and 520 deg. C. material improvements in both the tensile strength and the elongation were obtained. With 4 per cent copper, for instance, the tensile strength was raised by heat treatment from 9.5 to 15 tons per sq. in., and the elongation from 10 to 21 per cent. This is a rather remarkable result, but still more marked improvement by heat treatment was obtained with the Y alloy.

This alloy was first given a prolonged heating at 500 deg. C. to bring it to the same state as forged material. The temperature may be carried as high as 530 deg. without injuring the material. Next, the alloy was heat treated by heating to 480 deg. C. for six hours, either in an open muffle or in a salt bath, and then quenching in water. Still better results are obtained by quenching in boiling water or in oil.

Tensile Strength of Y Alloy, 1-Inch Diameter Chills

Treatment	Tensile Strength (Tons) At 15 deg. C.	At 250 deg. C.
As cast	12.6	10.5
Temp. 48 hrs. at 250 deg. C.	9.8	8.6
(1) Open muffle, 6 hrs. 480 deg. quenched and aged	14.9	11.3
6 hrs. 480 deg. and tempered 48 hrs. at 250 deg.	13.4	10.1
48 hrs. at 480 deg. quenched and aged	15.8	12.0
48 hrs. at 480 deg. and tempered 48 hrs. at 250 deg.	13.8	9.4†
(2) Nitrate bath, 6 hrs. 480 deg., quenched in oil and aged	14.6	12.8
6 hrs. at 480 deg. and tempered 48 hrs. at 250 deg.	13.2	11.0
48 hrs. at 480 deg., quenched and aged	16.0*	13.7
48 hrs. at 480 deg. and tempered 48 hrs. at 250 deg.	16.0	12.0
(3) Nitrate bath, 6 hrs. at 530 deg., quenched in boiling water and aged	21.0‡	

*Max. extension at 15 deg. C. 2.25 per cent in 2 in.
†Max. extension at 250 deg. C., 3.75 per cent in 2 in.
‡Extension at 15 deg. C., 6.5 per cent.

The marked improvement both at normal temperature and 250 deg. C. will be noticed. Prolonged heating has a very marked effect on the tensile strength of the material as cast, both at normal and high temperatures, but this effect is much reduced by heat treatment, which is important in a material intended for internal combustion engine pistons. The elongation is practically unaffected by the heat treatment. Heat treatment of the Y alloy is used at the Royal Airship Works at Cardington and it was there that a tensile strength of twenty tons was first obtained.

Progress Made in Forging Aluminum

IN the Eleventh Report of the Alloys Research Committee of the Institution of Mechanical Engineers, referred to in the earlier part of this article, extensive researches on wrought aluminum alloys are covered. The research work on which that report is based was done mainly with a view to developing alloys suitable for aircraft construction. Aluminum alloys that could be rolled into rods or sheets had been known for a long time, but these were all comparatively soft alloys of little strength, and the object of the researches was to develop alloys of greater strength that would lend themselves to rolling, drawing, extrusion, etc.

The first alloy experiment was with that known as Alloy A, consisting of aluminum 77, copper 3, zinc 20. It was found impossible to roll billets of this material without preliminary forging. Between 350 and 400 deg. C. the billets would stand a moderate amount of forging without cracking. At first the billet was rotated during the forging operation so as to distribute the blows evenly over the whole surface, but this was found invariably to result in cracking. The billet was then moved endwise so as to distribute the blows over the whole length, and was then rotated through an angle of 90 deg., after which an equal number of blows was given the billet on the side then up. By the method finally adopted the billet was reduced to an octagonal section, 5 to 10 per cent less in area, in two stages.

Much trouble was experienced from cracking during the breaking-down process in the rolls, and this was traced to surface defects in the cast billets. The trouble was finally overcome by tilting the billet molds at an angle of about 45 deg. to the horizontal and pouring the molten alloy in a slow stream. The object was to maintain in the mold at any time as shallow a layer of metal as possible, the rise in the liquid metal being arranged to keep pace with the rate of solidification of the alloy. This obviates all shrinkage cavities and largely avoids the necessity of "following up." This method of pouring, together with the plan of keeping the molds at a relatively low temperature (about 100 deg. C.) immediately improved the behavior of the billets in the rolls.

Annealing the billets at the maximum temperature short of incipient fusion did not improve the rolling qualities, nor did the use of lower breaking down temperature (300 deg. C.). Complete success was finally achieved by increasing the amount of forging and using a higher forging temperature (400 deg. C.). This was coupled with intermediate annealing between the first and second forg-

ing operations and a final annealing for one hour at 450 deg. C. before the rolling. It was also found necessary to keep the rolls well lubricated, as otherwise the billets would split in halves and curl around the rolls.

After billets had been broken down and rolled into rods of 1⅝ and 1¼ in. diameter, these rods could be readily rolled down further to ⅞ in. by reheating the rods as produced from the breaking down process to about 400 deg. C. The physical properties of the alloy vary slightly with the amount of rolling work done upon it, as may be seen from the following compilation.

Physical Properties of Alloy A (Rods)

Dia. of Rod Hot Rolled	Yield Point	Tens. Strength	Elongation
1⅝	17.8	25.4	16.5
	17.7	26.9	18.5
1¼	18.5	27.4	18.0
	16.2	26.1	19.0
⅞	16.5	26.1	22.0

The modulus of elasticity for this material was found to be 9,700,000 lb. per sq. in.

Experiments were also made in rolling this material into sheets, and in this connection it was found much better to use an annealing temperature of 250 deg. C. than 400-450 deg., which was the temperature range first tried. The advantage was especially great as regards the restoration of the ductility of the cold worked strip. Cold rolled and annealed material does not attain to the combination of tensile strength and elongation which can be readily obtained with hot rolled material that has never been cold worked. Cup-shaped spinnings were produced from alloy A with annealing at 250 deg. C., which proved entirely stable and remained sound for four years.

Annealing at lower temperatures than 250 deg. brought out the fact that cold rolled sheet after annealing for 30 minutes at 100 deg. C., shows a small amount of softening, while annealing at 180 deg. gives the maximum amount of softening, producing as much as 29 per cent elongation in 2 in. and a tensile strength as low as 19 tons.

Tests made on a specimen ½ in. in diameter by 2¾ in. long showed that when extruded and rolled, Alloy A (rolled to 1½ in. diameter from 2⅛ in. diameter) had an elastic limit of 10.4 tons, a buckling strength of 14.3 tons and a modulus of elasticity of 9,800,000. The proprietary alloy Duralumin, in specimens of the same form and treated in the same way, showed an elastic limit of 9.0 tons, a buckling strength of 13.7 tons and a modulus of elasticity of 10,100,000 lb. per sq. in. Tests gave a shearing strength for alloy A of 21.9 tons for sheet 0.048 in. thick and 23.3 tons for sheet 0.061 in. thick. Shear tests on rivets 0.063 in. in diameter gave a shearing strength of 15.8 tons for a single rivet joint and 17.3 tons for a double rivet joint. The reason for the lower shearing strength of the rivets, as compared with the sheet, is undoubtedly that the rivets were annealed. Yet the figures obtained with these rivets were much greater than those obtained with pure aluminum and soft alloys, which range between seven and eight tons.

Another composition experimented with is known as E alloy and consists of copper, 2.5; zinc, 20; magnesium, 0.5; manganese, 0.5; iron not to exceed 0.2; silicon not to exceed 0.2. After rolling billets of this alloy down to rods of ¾ in. diameter the following tensile properties were obtained:

Physical Properties of E Alloy

Primitive El. Limit	Yield Point	Tensile Strength	Elongation
22.1	32.9	37.8	12
18.9	32.1	36.8	11

This is claimed to constitute a considerable advance over any light alloy previously produced, so far as tensile properties are concerned, hence the committee devoted special attention to the development of alloys of this type and their production in the form of sheet by rolling.

In preparing alloys containing magnesium it was found that much better results were obtained by adding magnesium in the form of pure metal just before pouring than in the form of a high percentage magnesium (20 per cent) aluminum alloy, as the latter method produced unsound castings.

In working alloy E it was found that 300 deg. C. was the best forging temperature and that as much as 30 per cent reduction of area could be obtained without cracking. Results typical of tensile tests of alloy E after rolling to a thickness of 0.05 in. and after receiving the various forms of heat treatment indicated are given in the table below:

Tensile Tests of Alloy E in 18 Gage Sheet

Condition	Yield Point	Tensile Strength	Elongation
As hot rolled	26.3	31.4	15
	24.8	32.6	16
Ann. at 250 deg.	14.5	25.3	20
Quenched at 250 deg. and aged	13.7	23.3	22
Quenched at 350 deg. and aged	27.3	36.5	10
Quenched at 400 deg. and aged	27.8	38.7	9
	30.5	39.1	11

Production of alloy E was placed on an industrial scale at the Royal Airship Works at Cardington. Trouble occurred at first from excessive waste, due to edge cracking, but this was overcome by machining all billets before rolling and by a change in the composition. The conclusion was reached that the machining of slabs was cheaper than the rejection of all slabs showing surface defects. After the slabs are machined they are given a preliminary annealing before they are forged. This treatment permitted of a reduction in thickness of 30 per cent in the forging process, and after this the rolling process presented less difficulty. The addition of extra silicon, so as to bring the total amount up to 0.75 per cent, resulted in softening of the alloy, reducing the tensile strength from 39 to 35 tons and increasing the elongation from 15 to 18 per cent. With the additional amount of silicon the alloy is known as alloy F.

Alloy G is another modification of alloy E, in which the percentages of all alloying elements in the composition except copper are reduced to one half. The composition of alloy G, therefore, is as follows: Copper, 2.5; zinc, 1.8; magnesium, 0.35; manganese, 0.35; silicon, 0.80. This change in the composition produced very little diminution of the elastic limit but considerable increase in the elongation.

Alloy Y, originally developed for casting, had shown remarkable ductility within the temperature range 300-450 deg. C., which is usually employed for rolling, while alloys of the A and E type are remarkably deficient at these temperatures. For use in the connecting rods of internal combustion engines alloys containing a high percentage of zinc are useless. Type E also had shown certain limitations, due to the development of season cracking and corrosion. Alloy Y was studied particularly with a view to combining the high strength of zinc alloys with freedom from these defects. As regards tensile properties, on the whole, alloy Y gave the best results at both ordinary and high temperatures. At a temperature of 200 deg. C. alloy Y has a tensile strength of 19½ tons. This result was obtained in a test made on ⅞-in. diameter

rod previously heat treated by being quenched from 480 deg. C. in cold water and aged for four days. It appears that the hardening effect of heat treatment is removed by prolonged heating at 200 deg. C., as this tensile strength (19½ tons) is the same as that obtained from hot rolled rod. Temperatures up to 150 deg. C., however, do not seem to destroy the effects of heat treatment, as specimens held at this temperature for 100 hours showed only a negligible loss of strength. Comparison with alloys of the Duralumin type show alloy Y superior at 150 deg. in retaining hardness acquired by heat treatment. As alloy Y was intended for connecting rods, fatigue tests were made at 20-150 deg. C., and it was found that the safe ranges of alternating stress are ± 10.2 tons at 20 deg. and ± 8.4 tons at 150 deg. The range at 150 deg. was found to be higher than for any other alloy tested. It may be recalled that alloy Y contains 4 per cent of copper, 2 per cent of nickel and 1½ per cent of magnesium.

French Light Alloy Piston Work

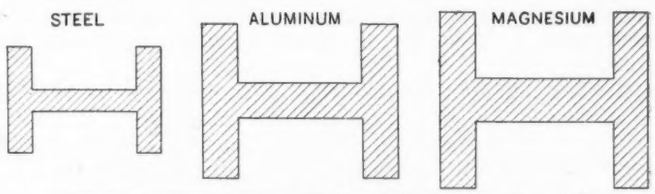
CAST magnesium pistons are being used this year for the first time on European racing cars and special speed productions. This type of piston was employed by Mercedes on the racing car which won the Targa Florio race, and cast magnesium pistons are being used on the French Rolland-Pilain two-litre racers built for the Grand Prix and other European contests. These pistons were cast by the Blanchaud Co. of Paris. The Fiat Co. of Italy also is experimenting with magnesium pistons. Other important uses of magnesium castings are to be found in the 500 hp. Bugatti-Breguet engines for the Breguet Leviathan plane. The crankcase of this 16-cylinder engine is a magnesium casting weighing only 99 lb., which is less by 55 lb. than the weight of the same casting in aluminum. This casting, which is one of the biggest and most important made in France up to this date, was produced by the Compagnie Parisienne de Fonderie with metal provided by the Societe de l'Electro-Chimie.

In Germany use is made of magnesium alloys described under the general title of Elektron, and produced by the Chemische Fabrik Griesheim-Elektron, near Frankfort. The most generally employed alloys appear to be magnesium and aluminum in the proportions of 90 and 10; magnesium, 85, and zinc, 15; or magnesium, 90, aluminum, 5, zinc, 5.

At the present time the greatest obstacle to the use of magnesium appears to be cost. Compared with aluminum there is a saving in weight of 33 per cent, but taking this into consideration the cost is double.

The Elektron Co. points out that this metal is inflammable if heated beyond its melting point, and that there is danger of fire if chips come in contact with water. The metal can only continue to burn, however, in thin sheets (sheet magnesium). As a proof that there is no danger of fire with magnesium alloy except when used in thin sheets, the following experiment was carried out in Germany. The engine was taken out of an old airplane and replaced by a gearbox in cast magnesium. The gasoline tank was filled and a light applied to the machine. In a few minutes the gasoline tank exploded and with the aid of a strong wind the entire plane was immediately in flames. After all the wood had been consumed parts of the magnesium casting fell to the ground, but they did not burn; the tail of the airplane dropped off, then the fuselage and the forward portion of the plane, which fell on the magnesium casting. The metal parts were only consumed slowly, and according to the official report the magnesium castings were the last portion of the plane to be burned.

Experiments have been carried out in France with both magnesium and aluminum connecting rods, but it appears that their use has been confined to experimental departments. M. De Fleury, head of a French aluminum foundry, has published particulars regarding aluminum and magnesium rods and pistons. While a steel rod and cast iron piston weighed 4.62 lb., the aluminum rod and piston weighed 3.08 lb. A magnesium connecting rod with two bolts and anti-friction bearing weighed 1.05 lb., compared with 1.38 lb. in aluminum. The sections of the three rods at the middle of their length were as shown in the sketch.



Diagrammatic sections of connecting rods of equal strength

These rods were for use in a cylinder having a bore of 3.38 in., with a compression ratio of 4.9. The three rods were of the same length, namely, 11 in. The explosion pressure per square centimeter was 347 lb. per sq. in. and the total pressure 3150 lb.

Aluminum Studies at Bureau of Mines

AN investigation is being made by Robert J. Anderson, metallurgist, at the Pittsburgh, Pa., Experiment Station of the Bureau of Mines of the effects of various metallurgical fluxes used in aluminum and aluminum-alloy melting practice. Worthless fluxes are to be given especial attention. Data have been obtained as to the different fluxes now used commercially and as to those suggested for use in melting. The effects of these are to be examined.

The Experiment Station is also conducting an investigation with the object of devising a rapid commercial method for the direct determination of metallic aluminum in aluminum, aluminum alloys, drosses, etc. A hydrogen evolution method has been developed for the direct determination of the metal. A complete account of the study is being prepared for issue as a technical paper.

A study is being made at Pittsburgh of the effects and interactions of the various gas constituents found in furnace atmospheres, e. g., carbon dioxide, carbon monoxide, oxygen, sulphur dioxide, water vapor, nitrogen, etc., upon aluminum at various temperatures. The available information, in the literature of the subject, has been col-

lected. Laboratory experiments are to be carried out.

The commercial use of pyrometry in aluminum and aluminum-alloy melting practice is being investigated. Data have been gathered as to the employment of pyrometric control of melting at commercial plants in the United States, and as to the types of pyrometers used.

A study is being made by the Bureau of Mines of the atmospheres in industrial furnaces used for melting aluminum and its light alloys. The purpose of the investigation was to ascertain the constitution of the atmospheres in contact with metal being melted in different furnaces by the analysis of gas samples taken from the furnaces. Samples of gas from practically all commercial types of industrial melting furnaces, both fuel-fired and electrically heated, have been taken and analyzed. A technical paper has been prepared, dealing with the sampling procedure and the results of the analysis, for publication by the Bureau.

The purpose of another investigation being made at Pittsburgh is to devise a rapid commercial method for the determination of aluminum oxide in aluminum and its light alloys, as well as to study the problem of aluminum oxidation in general. The methods suggested as suitable for this determination have been examined experimentally, and a number of new methods have been studied. The preliminary work done to date is being assembled in form for publication as a technical paper. It is intended that further study shall be made of this problem.

The effect of the quality of primary and secondary aluminum pig and aluminum-alloy pig in sand-casting practice as related to the quality of the resultant castings is being studied. Preliminary investigation, based on reports from foundries and other sources and on observation, has shown that difficulties are experienced in both foundry practice and in die-casting work, owing to variation in the quality of aluminum melting stock. This investigation may be regarded as continuous for the present. Some foundry experiments on the subject are under consideration.

A study has been made of the causes of, and methods for the prevention of, cracks in light aluminum-alloy castings. The investigation included also the determination of the contraction in volume and of the linear contraction of a series of commercial aluminum alloys, as well as an examination of the cracking tendency of the alloys when poured into different kinds of molds. In this connection an investigation was conducted with the purpose of measuring the total contraction in volume on freezing, and the linear contraction in different molds, of various light aluminum alloys. Measurements were made of the linear contraction in graphite molds of a series of commercial aluminum alloys and also of the total contraction in volume on freezing.

Investigations are also being made of the atmospheres in industrial furnaces used for melting aluminum and its light alloys. The purpose of the investigation is to ascertain the constitution of the atmospheres in contact with metal being melted in different furnaces by the analysis of gas samples taken from the furnaces. Samples of gas from practically all commercial types of industrial melting furnaces, both fuel-fired and electrically heated, have been taken and analyzed. A technical paper has been prepared, dealing with the sampling procedure and the results of the analysis for publication by the Bureau.

Thermal Expansion of Aluminum

SOME determinations of the coefficient of heat expansion of practically pure aluminum have recently been made at the Bureau of Standards. Pure aluminum has little use in automobiles, but presumably the coefficients of expansion for the ordinary alloys containing only small percentages of alloying elements are not very different. Two samples were cut from a bar of aluminum of high purity, prepared by the Aluminum Co. of America. The metal was melted in an Acheson graphite crucible at a temperature which at no time exceeded 1350 deg. Fahr. and was poured at 1300 deg. Fahr. in a green sand mold. The bar was taken directly from the mold and received no further heat treatment before the tests. The analysis of samples taken from the ends of the bar after it was cast was as follows:

	Per Cent
Silicon	0.12
Iron	0.13
Copper	0.006
Al. (by diff.)	99.744

The following table gives the results obtained for the average coefficient of expansion for various temperature ranges:

Coefficients of Expansion of Aluminum

Temperature range in degrees centigrade	Average coefficient Sample 1 (S613)	Average coefficient Sample 2 (S615)
20 to 100	23.7×10^{-6}	23.8×10^{-6}
100 to 200	25.4	26.1
200 to 300	27.3	27.0
300 to 400	29.8	30.2
400 to 500	32.3	32.9
500 to 600	35.9×10^{-6}	36.2×10^{-6}
20 to 300	25.6	25.7
300 to 600	32.7	33.1
20 to 600	29.3	29.5

The average equation

$$L_t = L_o[1 + (21.90\,t + 0.0120\,t^2)\ 10^{-6}]$$

is given as the most probable second-degree equation for the expansion of this aluminum (99.74 per cent) from room temperature to 600° C. The length at any temperature t as determined from this equation is accurate to $\pm$ 0.00004 per unit length.

The cooling curve was found to be slightly above the heating curve, and at the end of the test the specimen was about 0.01 per cent longer than before the test. The length of the other specimen was practically the same before and after the test.

A New Source of Aluminum

RECENTLY deposits of alunite, which contains 37 per cent of alumina, besides potassium sulphate, sulphuric acid and water, have been found in Tushar Mountains, Utah, and it is proposed to work these deposits for the manufacture of aluminum, potash and sulphuric acid. Although the alumina content of alunite is not as high as that of bauxite, it is believed that aluminum can be produced just as cheaply, if not more cheaply, from the former, on account of the valuable by-products, potash and sulphuric acid.

Potash is an important ingredient of fertilizers and sulphuric acid is widely used in the industries.

Research on Wood Products Aids Economical Automobile Production

Better bodies at a lower price depend largely upon fuller information about wood products. Forest Products Laboratory conducts practical research. Substitutes for ash determined. Preparing wood for bending studied. Moisture absorption through varnish is being investigated.

WOOD is extensively used in automobile and motor truck bodies and wheels, and to some extent in frames and minor parts. In aircraft construction it has so far been the chief material of construction, though attempts are now being made to replace it with light metal. The chief problems in connection with woods used in the automotive industry have to do with the procurement of sufficient stocks of faultless material; the substitution of other grades for the woods commonly used for certain purposes, in case of a shortage in the supply; seasoning or drying, storing, working, protecting against decay, etc. Most of the experimental or research work on wood is being done at the Forest Products Laboratory, Madison, Wis., an institution now in its twelfth year. The Laboratory did very effective work in connection with problems of aircraft construction during the war and has also published much material on the use of wood in automobiles.

One of the latest problems taken up by the Laboratory is that concerning the conditioning, finishing and protecting of wood. A preliminary meeting of representatives of interested organizations was held at Madison on May 3, at which it was decided to form a permanent organization by July 1 and to devise ways and means for carrying out the research. Although no automobile organization was represented at the preliminary meeting, it is believed that the automotive industry will be interested and will support the undertaking. A certain amount of work along the line indicated has already been done at the Laboratory, tests having been made of the rate of moisture absorption by wood when protected by different coatings. The research, when its results are published, no doubt will drive home the fact that the object in painting wooden structures and articles is to keep moisture out of the pores of the wood and thus prevent its decay.

A number of specific researches have been conducted which are of very direct importance to the automotive industry. A survey of the most important of these follows.

For use in automobile bodies ash has always been considered the most desirable wood. It combines the properties of moderate weight, easy workability, high degree of toughness, and comparative freedom from warping. On account of the high price of ash, however, other woods are replacing it in all but the most expensive cars.

The following description, prepared by the Forest Products Laboratory, gives some of the advantages and disadvantages of the substitute woods as compared with forest-grown ash for automobile construction:

Maple.—Hard maple is used for sills in many cars, and in some for the framework of the body and even the floor and running boards. Maple is fully as strong and stiff as a beam or post as white ash, but is not as shock-resistant. It is usually cheaper than ash and runs more uniform in strength. Maple warps very little, in this respect being superior to elm. On the other hand, maple is more difficult to season without checking than ash or elm, and it is said not to hold screws so well in motor car bodies. On account of the smooth, fine texture of maple, paint and enamel rub off it more easily, especially on curved surfaces which receive considerable wear, than off birch, which is slightly more porous. Because of its smooth wearing qualities and comparative freedom from slivers, maple is preferred to all other woods for the floors of delivery trucks.

Elm.—The principal use of elm is for frames, seat backs, and doors; very little, if any, is used for sills. White elm is preferred to rock elm, except for some of the bent parts, because it is more easily worked and is less subject to warping. For the same reasons lumber from old white elm trees, usually called "gray elm," is preferred to that from younger or vigorously growing trees. Old white elm is not so strong or tough as ash, on the average, but it varies less in strength than ash, especially that which comes from the southern swamps.

Birch.—Yellow birch is a close rival of maple. It is used for sills, framework and many minor parts. It is said to hold the paint better than maple on exposed parts.

Hickory.—The true hickories are used almost exclusively for spokes and felloes. The pecan hickories, which are somewhat inferior as a class to the true hickories, might be used in body construction, although their hardness and tendency to twist would perhaps prove a serious drawback.

Red Gum.—Red gum is too weak and soft for the sills and other major parts of the frame, but is used for floor boards, seat risers, and other minor parts. One of the principal drawbacks to the use of gum is its tendency to warp with changes in moisture content. Quarter-sawed gum gives less trouble in warping than plain-sawed gum.

Oak.—In automobile construction no distinction is made, as a rule, between the different species of oak or even between the red oak and white oak groups. In truck bodies, oak is one of the leading woods, being used for sills, cross sills, frames, floors, and stakes. In passenger cars oak is rarely used for the frame or sills. Wormy oak is used for running boards, floor boards, and seats, and some sound oak for instrument boards and battery boxes. Top bows are made almost exclusively of oak, second growth being preferred.

Southern Yellow Pine.—Under this heading are included longleaf, loblolly, shortleaf, and some of the minor southern pines. These have been found adaptable for running boards, floor boards, seat boards, and a number of small parts in the seats and frames.

Other Species.—Cottonwood is used for dashboards of passenger cars and the boxes or bodies of trucks. Sycamore, beech, basswood, yellow poplar, cucumber, tupelo, gum, chestnut, Douglas fir, and western yellow pine have also entered into car body construction to a small extent.

Seasoning by Means of Ozone

According to a recent issue of *Journée Industrielle*, Monsieur Otto, professor at the Sorbonne, has invented a process for seasoning timber by the use of ozone which accomplishes in twenty days what otherwise takes several years. The wood is subjected to the action of a current of air containing a certain percentage of ozone. A micrographic examination made by the laboratory of the Conservatoire des Arts et Métiers is reported to show that samples of oak and walnut which had been treated by the Otto process show the same characteristics as seasoned wood. The treatment does not change the color of the wood. The process is being worked by a French company, which has constructed works at Seregno, near Milan, and will shortly build new works in the neighborhood of Paris.

The comparative merits of the different species in the four properties most important in automobile construction are given in the following table, the strength of forest-grown white ash being taken as 100. Actual strength values of these species are to be found in Department of Agriculture Bulletin 556, "Mechanical Properties of Woods Grown in the United States":

STRENGTH OF WOODS USED IN AUTOMOBILE CONSTRUCTION IN PER CENT OF THE STRENGTH OF FOREST-GROWN WHITE ASH

Species	Strength as a beam or post	Stiffness	Shock resisting ability	Hardness
Hardwoods				
Ash, white, forest grown	100.0	100.0	100.0	100.0
Ash, black	71.3	79.3	90.1	62.3
Ash, white, second growth	122.5	117.6	119.6	118.9
Basswood	59.1	80.6	40.5	29.6
Beech	93.5	96.9	96.0	90.0
Birch, yellow	104.8	116.8	120.6	80.9
Chestnut	66.0	71.9	53.4	49.2
Cottonwood	60.6	79.0	54.3	35.3
Cucumber	85.4	112.4	76.7	54.9
Elm, rock or cork	98.8	92.9	140.5	101.6
Elm, white	79.2	79.5	89.5	57.1
Gum, red	80.7	91.5	75.5	59.0
Gum, tupelo or cotton	81.4	82.5	63.5	77.3
Hickories, pecan	103.5	103.8	119.7	139.6
Hickories, true	126.6	120.2	173.9	150.4
Maple, red	90.0	101.2	78.7	75.4
Maple, silver	66.9	68.5	71.7	64.3
Maple, sugar	104.7	105.9	90.5	103.0
Oaks, all kinds	92.6	101.3	94.9	104.5
Poplar, yellow	67.3	93.8	41.5	37.9
Conifers				
Fir, Douglas, Pac. Coast.	95.7	122.1	59.9	58.3
Pine, loblolly	93.7	105.6	71.0	60.0
Pine, long leaf	112.2	122.1	77.7	74.8
Pine, shortleaf	94.1	100.6	69.7	64.0
Pine, western white	75.5	99.7	53.8	37.0
Pine, western yellow	67.0	75.6	42.9	41.0
Spruce, Sitka	69.5	94.1	63.3	44.9

THE relative properties and performance of wood and metal wheels has been the subject of many tests. The growth in closed body production has made wood of growing importance. The researches which are being made in connection with wood products are of practical value to the automotive executive.

This article sums up the results of recent studies and shows their direct application to automotive practice. The facts are given in brief form, so that you can get a clear picture of the important developments in the study of wood as applied to automotive uses.

Bent wood is used in automobile construction in at least two forms—wood wheel felloes and steering wheel rims. To render wood pliable for bending requires both heat and moisture.

Experiments that were made at the Forest Products Laboratory indicate that enough moisture should be imparted to the wood to saturate the cell walls, which ordinarily means from 20 to 30 per cent moisture content. The pliability of wood apparently increases quite rapidly with increase of temperature. Very high temperatures, such as accompany steam under pressure, however, are not advisable, since they render the wood brash; in fact, boiling for any length of time permanently reduces the strength and toughness of wood to small fractions of their normal values.

Freshly cut stock is, of course, thoroughly saturated and needs no additional moisture. Only heat is required to produce flexibility. If the stock has dried for a long time, it will have a uniformly low moisture content throughout, probably 12 to 15 per cent. Such material requires the addition of a considerable amount of moisture before it is in proper condition for bending. If the stock has dried for a shorter period, the interior part may be at a high moisture content, while the exterior surfaces are quite dry. Such stock needs the addition of sufficient moisture to bring each part of it up to about 25 per cent.

Condensation of the steam may not furnish sufficient water if the stock is very dry; in this case the addition of a hot-water spray to play on the stock in the steam box would be advantageous. Admission of the steam through water will insure its being thoroughly wet. Pressure steam probably adds very little if any to the moisture content.

Steaming of Vehicle Stock During Kiln Drying

Saturated steam as a means of alleviating the tendencies of green lumber to honeycomb in the kiln has for some time been successfully applied in the commercial drying of heavy vehicle stock. So far the treatment has been confined to straight stock. The contention has always been that bent stock, such as rims, should not be steamed after removal from the form, experience indicating that stock so treated would tend to straighten out to its original shape. The kiln-drying of heavy, bent rims has been carried on, therefore, without resorting to steaming to remove case-hardening and other defects of drying.

Recent experiments conducted under the direction of the Forest Products Laboratory have shown that judicious steaming of heavy, bent vehicle stock results in a considerably improved product, and that the operation can be accomplished without serious effect upon the curvature. Careful judgment is necessary, however, as it is a very easy matter to ruin the entire charge by too severe treatment. This steaming has been done at high temperatures (150 deg. to 180 deg. Fahr.) and for short periods (one-half to three hours), the temperature and time varying according to the requirement of the case.

The method was given a rather severe test, being tried first on 56-in. oak rims and later on 60-in. artillery wheel stock. From kiln charges totaling about 2400 pieces, the losses attributable to kiln-drying were only 2 per cent.

Highway Research Brings Economical Transportation

Proper road location reduces construction and operating costs. Maintenance studies in progress. Knowledge of subsoils increasing. Test roads give help for future building. Construction economy through study of methods. Activities coordinated by Advisory Board on Highway Research.

By W. K. Hatt*

HIGHWAY research must be conducted in a somewhat critical mood. The impression prevails that a large part of our present data is unreliable partly because they have been obtained under conditions which no longer prevail, and partly because the data are misleading without the knowledge of underlying conditions. Hearsay evidence, rumors and propaganda are not wanting. Unproven statements should be eliminated. Mere argument, unsupported by facts, must be disregarded, and final decisions based upon authoritative and vital data.

THERE is an important service to be rendered by the highway engineer in so locating his road that the cost of operation will be reduced, these costs including fixed charges, depreciation, replacement, maintenance of vehicle and road, etc. Professor T. R. Agg of Iowa State College has accumulated a large amount of very carefully determined data in connection with the work of the Engineering Experiment Station of the College, and he is also directing work in New England in which Harvard University, Yale University, Massachusetts Institute of Technology, Bureau of Public Roads, United States Army, Society of Automotive Engineers and the highway commissions of Massachusetts and Connecticut are co-operating.

Maintenance

Maintenance costs, one of the most important elements entering into the economics of highway construction, have in the past not been properly determined and allocated. The choice of the type of road depends greatly upon such data. Something more is needed than a total cost of maintenance from fence-to-fence or from shoulder-to-shoulder. We should know the cost arising from the surface itself, and whether this was a replacement or the result of a misfit of the type to traffic conditions. The Bureau of Public Roads will require a report on maintenance costs on all federal aid projects according to a standardized system of accounting. In the course of time reliable maintenance data may be secured. In the meantime much can be learned from specific cases, particularly in those counties where foresighted individuals have properly analyzed maintenance costs.

Maintenance of roads must assume a larger importance as the construction program becomes more complete. A great deal of experimentation and research is needed to fix upon the correct theory of maintenance of the various classes of roads. An interesting experiment in the maintenance of a wide gravel road under the direction of Mr. A. R. Hirst of Wisconsin shows the possibility of useful research in this line. Here a layer of fine gravel is maintained on the surface by drags.

The Michigan State Highway Department has under way an interesting experiment to determine the efficiency of various dust preventives.

Dr. G. E. Ladd of the Bureau of Public Roads has completed a report upon its study of corrugations in gravel roads in eight different states. Contrary to the general impression of drivers, these waves which have been so expensive in the maintenance of roads and the maintenance of vehicles, are from 25 to 35 in. in length, crest to crest, and have a maximum height of 1½ in. unless pitting and ravelling have begun. These corrugations develop rapidly from the action of motor vehicles when the traffic reaches 400 cars per day. Generally in gravel roads they originate in the kick-back of surface materials arising from the spin of one or both of the rear wheels as they descend from a bounce over some obstacle or depression. Spring action has undoubtedly a contributing and modifying effect. Engineers are not agreed upon the most favorable materials or upon the effect of dust preventives to prevent corrugations. Planers, drags and scrapers are used to cut down and erase corrugations, with some success. Scarification and subsequent recompaction by traffic is a heroic treatment.

The problem of the sand-clay or top-soil road, which must furnish the main transportation for large regions of the South Atlantic states, is being studied in Georgia and North Carolina. Professor C. M. Strahan of the University of Georgia has developed data that serve to define the per cent of clay and coarse sand which will render these roads stable under a traffic which they can reasonably be expected to carry. The Bureau of Public Roads and the North Carolina Highway Commission are also investigating this type of road to determine the limit of traffic under which they may be maintained, and a means of improving and extending the life of the surface. In one experiment broken stone is rolled in the surface of a sand-clay road to serve as an anchor for a bituminous mat subsequently placed.

IN the fields of economics and operation but few references can be made to research activities, although it must be said that there is a live appreciation of the urgent necessity of early studies. In the field of design, however, the engineers are in a more favorable position, because

*Director, Advisory Board on Highway Research, National Research Council.

the fundamental mechanical principles of the operation of the various types of roads are being defined rapidly. Of course the problem is simple in statement. Given the maximum weight and volume of traffic; to provide a road of sufficient width and strength to carry this traffic over the existing or improved subgrade. The solution must depend upon the characteristics of the region, and will be different in Arizona and Massachusetts. Regional supplies of material and labor and climatic conditions certainly influence the result. The main problems of research lie in the load, the mechanical action of rigid and non-rigid slabs and the properties of the subgrade.

THE highway engineer must face all kinds of sub-soils, such as the adobe soil of California, which cracks and swells in a remarkable way, sufficiently at times to deform the green concrete of the road slab, the black soils of Illinois, plastic clays and gravel. The design of the road should be related in some manner to the supporting power of the soil. A large volume of research is directed to the study of sub-soils and particularly to determine that element of the soil which determines its properties and to the treatment of sub-soils by drainage and the admixture of chemical additions. The most important agencies in this field are the Bureau of Public Roads, the Sub-Soil Committee under the chairmanship of General T. Coleman Dupont, organized first as a committee of the now inactive Federal Highway Council, the work by Professor Eno of the Ohio State University, by Clifford Older of the Illinois State Highway Department, by the University of California and Dean Marston of Iowa. These researches include the mechanical and ultimate analysis of soils, instruments for determining bearing power and study of water movement and consequent volume changes. Studies are also under way in the Bureau of Public Roads for the protection of the shoulders and other means to preserve the moisture content of the sub-soil more uniform. In California the soil is improved by mixing in coarse aggregate. In some states a layer of tarred paper is placed in the sub-soil to prevent the entrance and egress of water which it is thought results in harmful volume changes of the concrete slab. When the studies under way are complete we should have within the year a fairly satisfactory account of the action of sub-soils, the means of testing them and the implication which the data carry into the field of design. It is Mr. Older's observation that in the case of the soils of Illinois there is practically no supporting power under expected conditions, and that therefore the concrete slab must be designed as an overhanging cantilever with the load at the corner of the slab. The Bureau of Public Roads has treated some sub-soils by the admixture of additional materials such as Portland cement which apparently renders a plastic clay granular in its nature and destroys the plasticity. Experiments are under way by the California State Commission on various methods of treating adobe sub-soils.

The Pittsburg, California, test road, including twelve different designs of concrete road slabs, has been interrupted, after carrying 3,500,000 tons, on account of the failure of some of the weaker sections. No substantial surface wear of the concrete is observed. Arrangements are made for replacing these and continuing the tests until the stronger sections, viz. those with inverted curb, are broken. This test has already decided the policy in choosing types of pavements in Arizona. The Pittsburg test road, which has cost in the neighborhood of $200,000, will repay many times the cost of its construction in the value of the information furnished. This test was originated by a private corporation but may be continued by the State of California and the U. S. Bureau of Public Roads.

The Bates test road in Illinois, after passing through almost two years of exposure to climatic changes, is now being loaded to destruction with motor trucks. In this road various types of pavement embodying weak and strong concrete, thick and thin sections, brick and bituminous covers, present a wide range of type.

The experiments of the Bureau of Public Roads at Washington wherein slabs of various design are subjected to impact tests, which have been connected up with the service blows from truck traffic, have disclosed some fundamental principles of subgrade and pavement resistance.

Results are now appearing from the experimental concrete highway 2 miles long constructed in Alexandria County, Virginia, under the direction of the U. S. Bureau of Public Roads. The road presents sections of various thicknesses and shapes, with various reinforcement.

The experimental road, circular track on concrete base with bituminous top, has been built by the U. S. Bureau of Public Roads at the Experimental Farm, Virginia. Various combinations of bituminous tops are to be tested under the action of a truck which is guided mechanically. A portion of this track 4 ft. wide will be surfaced with concrete containing various aggregates to determine their resistance to wear.

There are several roads built containing variations in aggregate or reinforcing as part of state systems, the data of which are at present being compiled.

MOST discussions of highway construction are so highly technical that the automotive executive isn't much interested in them. They are of interest only to the expert engaged in road building work.

But future car and truck sales are so strongly dependent upon properly constructed and properly maintained highways that every executive in the automotive industry is really concerned very deeply in the progress of highway research studies.

Consequently we have asked Prof. W. K. Hatt, Director of the Advisory Board on Highway Research, to tell the story of highway research in a brief human way that will give you the essential information in interesting readable form. The accompanying article is the result of that request. Read it and see if you don't think Professor Hatt has accomplished just what was requested.

THE Bureau of Public Roads is co-operating with the Asphalt Association in studying the causes of waving of asphalt pavements. A large number of samples have been secured from Washington, Baltimore, New York, Philadelphia and Detroit for laboratory study.

These researches in Washington, Illinois and California are surrounded with highly advanced technique and produce data which will be of general value in engineering design. When the results are gathered together and analyzed it is expected that engineers can intelligently design stiff slabs to carry a specified load over a determined subgrade. These researches alone probably involve an expenditure of three-quarters of a million dollars, a sum of minor importance in view of the hundreds of millions of dollars to be expended in the construction of such roads.

The last word has not yet been said on the policy of reinforcing concrete roads. One extreme is a thick, heavy

slab, massive enough to withstand such loads as are found in the state of Washington, viz. 20 tons of logs; the other extreme is a thin flexible slab which will deform under a load or under the action of frost and be brought back to its primitive shape by the elasticity of the reinforcing steel. No doubt the adjustment in this respect would be determined by the condition of supply of materials and by a comparison of the maintenance costs of heavy concrete roads and thinner reinforced roads. The amount of reinforcing now generally used is only sufficient to hold together the broken sections of the concrete slab. Research is needed to determine the amount of reinforcing which will be really effective under the various regional conditions of this country. The results of the Pittsburg tests point to the value of massive plain sections with stiffened edges under the conditions there obtaining.

It would seem that in the rapid development of other types of roads the experimental study of brick roads has been somewhat neglected, and we should welcome the efforts of the National Association of Paving Brick Manufacturers to promote research comparable to that now being applied to other types of construction. Favorable reports have been received from inspection of brick roads filled with bitumen and supported on a rolled stone base in Ohio. The limits of this paper will not permit the further discussion of types of roads.

Construction

A RESEARCH into the efficiency of the operations of concrete mixers is much needed and also a further study of the product of central mixing plants.

The field of research on the fundamental principles of materials and on standardization of tests has been occupied for a great many years. These researches are well fitted to the ordinary university laboratory and are numerous. It is not within the scope of this paper to mention them. Perhaps special mention may be made of the following without doing injustice to the large number of devoted and able experimenters.

The work of Prof. Duff A. Abrams of the Lewis Institute has made it now possible for expert testing engineers to duplicate tests of concrete cylinders in the laboratory with very close agreement. However, field tests of concrete cylinders scatter very widely even when they are made with great care by trained operators. At present it may be asked, if field tests of concrete cylinders in compression are indices of the concrete in the road? Are such tests a suitable basis for contractual relations? The practice of cutting cores from the hardened concrete roads is common, but the returns are not sufficient to allow judgment. The work of the Pennsylvania Highway Commission, the Illinois Highway Commission, the University of Illinois and the Maryland Highway Commission, when brought together, will throw light upon this question.

Survey of supplies of road materials by which bidders on highway construction may know the available sources of acceptable material, quarry condition and freight rates, such as are conducted by the Pennsylvania and North Carolina State Highway Commissions, result in an easily computable saving of money to the States. Mr. I. W. Crum, testing engineer of the Iowa Highway Commission, and Prof. M. O. Withey of the University of Wisconsin and the Purdue University Laboratory, have given special attention to the use of available aggregates. The Kansas State Agricultural College and the Texas Highway Commission are both active in the field of development of materials of construction.

Road Materials Survey

THE work of Mr. W. L. Schwalbe in the study of consistency, at the University of Illinois, is likely to prove of great value. At Purdue University a survey of road materials in the State is under way, and also studies of the test for surface hardness of concrete.

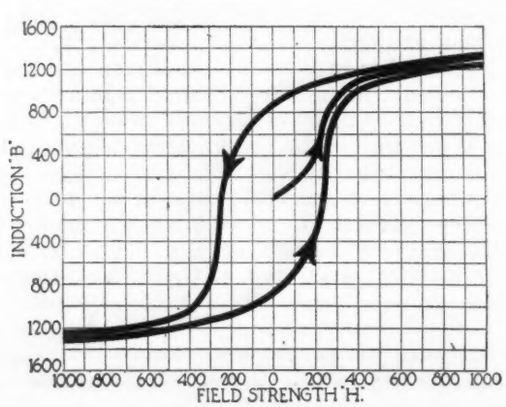
The ability of plain concrete to withstand reversed and repeated stresses is being investigated at the University of Maryland by Dean A. N. Johnson, who has devised a machine that will bend beams 2/100 of an inch at the rate of 200 times each minute. The Illinois Highway Commission and Purdue University are also experimenting in this field. Indications are that repeated loads below 50 per cent of the ultimate once-applied load can be applied hundreds of thousands of times without resultant failure of the concrete.

A little later the Research Council will expect to issue the results of a Census of Research in which the many valuable studies under way in the Experiment Stations of the various State universities will be listed and described. It is difficult to maintain a few of these investigations in a paper of this kind without doing injustice to the large number of devoted research workers.

Research upon structures such as highway bridges can only be mentioned because the limits of space have already been exceeded.

Cobalt Steel for Permanent Magnets

H. TAGAKI and K. Honda have made researches on alloy steels for permanent magnets. These are called K. S. steels and their composition varies between the following limits: Carbon, 0.4 and 0.8 per cent; cobalt, 30-40 per cent; tungsten, 5-9 per cent; chromium, 1.5 to 3 per cent. These steels are quenched at 950 deg. C. (1740 deg. Fahr.) in oil.



Samples of this steel were placed in a magnetic field having a strength of 1500 gausses; they showed a remanent magnetism varying between 920 and 620 c.g.s. units. Their coercive force varied between 226 and 257 gausses and is approximately thrice as great as that of the best tungsten steel. Fig. 1 shows the hysteresis curve of one of these samples which was in the form of a cylinder 20 cm. (8 in.) long and 5 mm. (0.2 in.) diameter. The energy absorbed by hysteresis in one cycle is approximately 909,000 ergs, while with the best tungsten steel it would have been 290,000 ergs. The experiments and their results are described in *The Physical Review* for December, 1920.

Non-Ferrous Metal Research Affects Design of Small Automotive Parts

New coefficient of expansion determined for nickel. Properties of monel metal examined. Research shows best flux for use in brazing with high-melting point brass. Bureau of Mines and Institute of Metals to collaborate for non-ferrous metal research. Bureau of Standards active.

FEW of the non-ferrous metals, other than the light metals and alloys, are used in the automotive industry to any great extent. Many automobile parts that were formerly made of brass and bronze are now made of steel, the development of metal pressing and forging and of rust-proofing processes having made the use of the cheaper metal practicable. Copper is used to a certain extent in tubing and in radiator cores and exclusively for the current-carrying parts of electrical equipment.

Brass is sometimes used for radiator cores and tanks, as well as for carbureter bodies, lubrication and other small fittings and for some brackets. Bronze is used for worm wheels and pump impellers, babbitt or white metal for all engine bearings, tungsten for vibrator contacts, nickel for spark plug electrodes and monel metal for float valves. Considerable research work has been carried on in connection with bearing metals, mainly with a view to the use of lead as an element of the alloy, but most of this seems to have been of a competitive nature and is not at present available for publication.

In addition to the non-ferrous alloys used as materials of construction in the automotive industry there are the heat resisting alloys which are largely used in crucibles for heat treatment and which have also been adapted to use in poppet valves. Research along this line is also going on constantly.

Thermal Expansion of Commercial Nickel

THE thermal expansion of nickel is of particular interest, for the reason that the electrodes of spark plugs are made frequently of almost pure nickel, and as the central electrode is embedded in the porcelain, the latter is apt to crack if there is too great a difference in the heat expansion of the nickel and the porcelain. In view of this fact the Bureau of Standards has recently made a redetermination of the coefficient of expansion of nickel. The results are embodied in Scientific Paper No. 426, of which Wilmer H. Souder and Peter Hidnert are the authors.

It appears that the first determination of the heat expansion coefficient of nickel was made by Fizeau in 1869 and yielded the value 0.00001279 at 40 deg. C. Thirty years later Tutton made nine individual determinations and found that between 6 and 121 deg. C. the expansion coefficient may be represented by the equation

$$0.00001248 - 0.0000000148\ t \text{ or } 10^{-5}\ (1248 - 1.48\ t)$$

Holborn and Day found that nickel undergoes a transformation at about 300 deg. C., and as a result the test bar, which at the beginning was 482.6 mm. long at 0 deg. C. was approximately 0.02 mm. shorter at the conclusion of the tests.

In the investigation at the Bureau of Standards determinations were made on the thermal expansions of ten different samples of commercial nickel from room temperature to about 600 deg. C. The nickel content varied from about 94 to 99 per cent. Five samples were hot rolled and the remaining samples were hot rolled and then annealed.

The results showed that annealing of hot rolled nickel generally increases the heat expansion coefficient. The average coefficients between 25 and 300 deg. C. for the samples containing 98.76 to 99.06 per cent of nickel are 14.4×10^{-6} for the hot rolled and 14.5×10^{-6} for the annealed specimens. For the range from 25 to 600 deg. C. the coefficients of the five hot rolled samples vary from 14.9×10^{-6} to 15.6×10^{-6} and for the five annealed specimens from 15.4 to 15.7×10^{-6}. These coefficients are considerably greater than those which the bureau has found to apply to porcelains used in spark plugs.

The average coefficient of expansion of the ten samples between 25 and 100 deg. C. varies between 12.9×10^{-6} and 13.5×10^{-6}. These coefficients are approximately 10 or 20 per cent greater than those of ordinary steel for the same range.

On cooling from the maximum temperature of 600 deg. C. to room temperature the observations were generally slightly below the heating curve, so that after the thermal expansion tests the specimens were generally

slightly shorter than before the tests. This corroborates the experiments of Holborn and Day, though the experiments of Harrison showed that nickel wire in each case returned to its original length after heating.

Heat Expansion of Monel Metal

MONEL metal is a natural alloy containing approximately 67 per cent nickel, 28 per cent copper and 5 per cent of other elements such as iron, manganese, silicon, etc. The Bureau of Standards has recently made determinations of the heat expansion coefficient of this alloy. Measurements were made on ten samples from room temperature to about 600 deg. C. Two samples were cast and three were hot rolled. The remaining five specimens, of the same compositions, were annealed in addition.

The expansion curves on heating were found to be fairly regular. On cooling, the observations were slightly below the heating curves in most cases. The average coefficients for the range from 25 to 300 deg. are all practically equal. Above 300 deg. there are some marked differences. For instance, one sample containing 2.22 per cent of lead has a coefficient of expansion of 20.6×10^{-6} between 500 and 600 deg. C., whereas another sample of the same composition but annealed at 1650 deg. F. for one hour had a coefficient of expansion of 18.3×10^{-6} for the same temperature range. In most cases the coefficients of the annealed and unannealed specimens were about equal.

Monel metal contains a large percentage of copper and the coefficients of expansion of this metal are greater than that of nickel but less than that of copper. The samples of monel metal containing lead showed the greatest coefficient of expansion. The coefficient for all specimens increase with the temperature, the most notable increase being observed in the case of the leaded monel metal, from 13.9×10^{-6} for 25 to 100 deg. C. to 20.6 for 500 to 600 deg. C. Between 200 and 300 deg. C. the coefficients of all the specimens are most nearly alike, the minimum being 15.5×10^{-6} and the maximum 15.9×10^{-6}.

Dip Brazing with High-Melting Point Brass

AN investigation of various factors in brazing has been made at McCook Field and the results so far obtained are published in a recent issue of the Air Service Information Circular. The particular object of this research is to determine the best flux for use in brazing with 80 copper-20 zinc brass, to determine the effect of heat treatment on brazed joints, to develop a satisfactory method of brazing with 80-20 brass, to ascertain the relative values of the 80-20 brass and an alloy consisting of 74 copper 20 zinc and 6 nickel for dip brazing, and to ascertain the proper brazing temperature and clearance for this method of brazing.

The round specimens which were to be used for making the butt brazed joints were cut in the middle and the ends faced off true in the lathe. These specimens were left approximately 0.08 in. oversize at the middle before brazing and no threads were cut on the ends until after the brazing operation. In order to hold the two parts of each butt specimen in place while brazing, two steel strips, or stays, were welded to opposite sides of the specimen by means of the acetylene torch, care being taken to align the two parts as nearly as possible. The heating of the specimen during the welding of the stays was confined as much as possible to the ends, and there it was very much localized. The middle part, where the braze was to be, never became hotter than 1000 or 1100 deg. F. during the welding of the stays. The temperature at that point was purposely kept low to prevent excessive oxidation on the surfaces to be brazed.

The specimens for the lap joints were held in place for brazing by means of two 1/16 in. rivets for each specimen inserted near the ends of the lap at such distance from each other that the required length of lap existed in the clear between the rivets. As in the case of the butt specimens, the lap specimens were left oversize to allow for cleaning up after brazing. In order that the joints might be firm after riveting and still leave a clearance to permit the brass to enter, the tip end of each piece was upset slightly with a hammer before riveting.

Then after the rivets had been inserted, they were drawn down with the hammer until only a perceptible gap was left. The surfaces of the steel were ground before assembling to remove all scale that might be present. To facilitate dipping of the sheet specimens, a ¼-in. hole was drilled in the end of each specimen through which a wire could be inserted to suspend the specimen when dipping in the brass. The round or butt specimens were suspended by inserting a wire under one of the stays that were welded along the sides.

Owing to the irregularity of the results obtained with the lapped tensile specimens just described, a shear specimen was designed and used on all the later work on brazing. The butt specimens, while giving fairly uniform results, were extremely difficult to manipulate and so were discarded.

The shear specimens were made of ¼-in. stock, lapped about ⅝ in. and riveted at each end, making a specimen approximately 1½ in. in length with a distance between the rivets slightly exceeding an inch. A hole was drilled in one corner through which a wire could be inserted for convenience in brazing. After the brazing had been completed both ends of the specimen were cut off, thus re-

SMALL improvements and minor refinements will play a part of increasing importance in automobile selling and designing as time goes on. The general principles have been well laid down and accepted. The difference between the gasoline engine of today and that of 1910 is largely one of minor improvements.

This tendency gives a special interest to the research work which is being conducted as regards non-ferrous metals. Such materials are used in limited quantities by the automotive industry, but the small parts for which they are used are important to future selling and manufacturing.

moving the rivets, and the area of the lap was reduced to exactly ½ sq. in.

The special strap specimens were made for the purpose of determining whether the length of the specimen influenced the results of heat treatment. They were made 6 in. long with a longitudinal lap about ¾ in. wide, and held together by spot welding with the oxygen-acetylene torch. They were designed to be broken apart with a hammer to ascertain the character of the braze after heat treatment.

The following conclusions were arrived at:

Conclusions

Preheating to a dull red heat just before brazing is found desirable, but a higher temperature or continued heating hould be avoided on account of oxidation of the surfaces to be brazed.

Borax gives the best joint when brazing with 80-20 brass, but should be used in connection with a cooling flux, preferably boric acid, in order to prevent surface oxidation of the specimen.

It is found advisable to coat the parts to be brazed with a borax-boric acid paste to prevent oxidation during preheating.

The proper brazing temperature is found to be 1850 deg. F.

The best joints are obtained when the surfaces to be brazed are fastened close to each other by any suitable means without the use of shims or spacers.

The strength in pure tension of joints made on carbon steel, untreated, is approximately equal to the strength of the brass in tension. That of the nickel-steel joints, heat treated, is nearly twice the strength of the brass. The strength of joints in pure shear is approximately equal to the shearing strength of the brass. This shearing strength is also approximately equal to the tensile strength of the brass.

Nickel-steel joints tested in shear give approximately the same results as carbon steel.

Heat treatment of brazed parts is shown to be successful on certain types of specimens brazed with 80-20 brass, but unsuccessful on one particular type.

Organization for Non-Ferrous Alloy Research Deferred

A CONFERENCE of the Advisory Committee on Non-Ferrous Alloys of the Institute of Metals Division of the American Mining and Metallurgical Engineers with representatives of the United States Bureau of Mines was held at the Bureau of Mines, Washington, D. C., April 25. This was the second meeting held for the purpose of developing a program of co-operation between the non-ferrous metal industries, as represented by the Institute of Metals Advisory Committee, and the Bureau of Mines, with especial reference to the non-ferrous work of the latter organization.

The conference discussed the question of the functions and possibility of development of the proposed Alloys Research Association, now known as the Alloys Research Information Service. As originally proposed, it was the idea to receive contributions of $250 each from firms in the non-ferrous metal industry for promoting a central information service. A fund of $40,000 was required for this work, which would begin as an information and abstracting service and later develop into a central research laboratory. The feeling was that, owing to the depressed industrial situation, it would not be a propitious time to push the matter. Members representing industrial concerns stated that their companies would be willing to enter such an association when conditions are better.

The Bureau of Standards has completed the examination of five bronzes for impurities, with the purpose of establishing the spectographic method for quantitative estimation of small amounts of aluminum and silicon, which are detrimental in bronze or brass castings. The method is simple, successful and sufficiently accurate. A report on this practical application of spectrum analysis was presented at the Non-Ferrous Metals Committee meeting on April 24.

Research Work at University of Illinois

FOLLOWING is an outline of the research work under way at the Engineering Experiment Station, University of Illinois, which should prove of interest to the automotive industry:

(1) *An investigation of the fatigue phenomena of metals.* This investigation is a co-operative one, a large grant of money having been made to the Station by the Engineering Foundation and the General Electric Company. One bulletin, No. 124, has already been distributed. This work will probably continue for several months until the funds provided have been exhausted. It is hoped that manufacturers of metal products will provide additional grants of money to continue this investigation until there seems to be little advantage in proceeding farther with it. It is the most elaborate study of the subject ever undertaken, and already many very important facts have been established.

(2) *Highway construction.* We have undertaken some work on certain phases of highway construction which may be of some interest. These include a study of the effects of temperature upon concrete road slabs; a study of the effects of moisture on such slabs; a study of the re-enforcing of concrete roads, and a study of oiled dirt roads.

(3) *A study of the explosion of gaseous mixtures,* which includes an elaborate investigation of the effects of the shape of the combustion chamber of an internal combustion engine, the effects of turbulence, of various fuel mixtures, etc.

THE decree permitting the free importation into Russia of motor cars for state and private use has, it is reported, brought many offers from foreign firms. The Foreign Trade Commissariat is negotiating with foreign motor car manufacturers to establish branches in Russia on a mixed corporation basis. German, American and Italian companies, according to the Russian Trade Delegation, propose to institute omnibus and motor truck services to link up with railway stations, and also to construct an interurban railway from Moscow.

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The First Research Survey

WE have aimed to give a comprehensive picture in this issue of the various research activities from which the automotive industry will benefit. Every effort has been made to cover the field thoroughly.

The co-operation of many companies and individuals throughout the industry was essential to success in this attempt. The frankness with which many manufacturers told us about their research work has been gratifying and we take this opportunity to express our hearty appreciation to them.

A general spirit of openness and desire to exchange information has prevailed, although there are numerous instances of firms unwilling to exchange information freely with other manufacturers. This general frankness, however, is typical of the progressive spirit of the automotive industry which has been so largely responsible for its rapid growth. Through the frank exchange of ideas and results progress for everyone is facilitated and each company is benefited.

"When you shut the laboratory door you shut out more than you shut in," says Kettering. This is the spirit which has made possible this our research number and which will mean continued progress for our industry.

The very nature of the task made it impossible to paint a complete picture at this first attempt. Nothing of a similar nature has been done before, and there has been a necessity of explaining the idea to many people within a brief space of time.

Our purpose has been to give you both information and inspiration. We hope we have achieved our purpose, at least to some limited extent. How well we have succeeded in this attempt to show the importance and the results of automotive research will be judged by our readers.

Deprecating the Straight Side Tire

REFERENCE has been made in these columns previously to the propaganda of certain European tire manufacturers against the straight side tire. These same manufacturers have just discovered another disadvantage inherent in the straight side construction—that it renders steering more difficult. The argument is somewhat as follows: The straight side tire with its rim is heavier than the clincher tire and its rim, and in a modern racing car the difference amounts to as much as 16 to 20 lb. (which applies probably to all four wheels). Practically all of the additional weight is at the rim of the wheel. Now, a wheel rotating at high speed acts like a gyroscope, tending to resist any change in the plane of its rotation. Therefore, when the driver operates the steering hand wheel to turn a corner, he has to exert a greater effort with the heavier wheels, those with the straight side tires. The difference is said to be so great that experienced and well-trained men will find themselves tired out after four or five hundred miles with straight side tires.

Evidently this statement is meant to apply to racing conditions, as in touring it is very seldom that one wants to drive continuously for four or five hundred miles at high speed, and corners especially should be taken at low speed, for the sake of safety. Little objection can be found with the above statement *per se;* it would be a wonder if a driver after such a task were still fresh and without signs of fatigue. The trouble is not with the statement itself but with the obvious inference that with clincher tires the driver would not be tired out.

We fully realize that it is impossible to settle this matter by argument, because there are too many indeterminate factors involved, such as character of route, condition of road surface, sensitiveness of the steering mechanism, etc. Besides, fatigue is a rather indefinite thing itself, not subject to measurement, we believe.

There evidently has been considerable difficulty in getting race drivers to use clincher tires on the short, tortuous routes of European road races, on account of the danger involved in shedding a tire when going at high speed, and rather far-fetched arguments are

seized upon to bolster up the case of the clincher with the racing fraternity. This tendency of the clincher to leave the rim when deflated seems now to have been overcome, and while this improvement is to be welcomed, it does not affect the chief reason for preferring the straight side for general service, which is its comparative freedom from rim cutting.

Utilizing Existing Research Facilities

THERE are few if any better equipped laboratories for research work in this country than those at the Bureau of Standards in Washington. This applies to facilities for automotive research as well as to equipment for investigations in related and non-related fields. Funds for the conduct of research work at the Bureau are not solicited from the industries concerned or from any private source. They are appropriated by Congressional action from public funds, but Congress is largely influenced in making the appropriations by expressions as to the desire of the industries concerned. Any piece of research work which is urgently needed by a given industry will be undertaken by the Bureau, within the scope of its facilities, if the funds required are appropriated, but to bring this about the industry concerned must make it clear to Congress that the work is needed and is in the public interest. The Bureau can formulate a program and ask for the funds to carry it through, but these funds are seldom provided unless those who will benefit thereby have enough interest in the program to urge upon the Congressional appropriating committees the need for favorable action on the request for funds.

This year a constructive and highly important program was laid out by the Bureau, but the funds required were denied by a close vote in committee for lack of sufficient support on the part of the automotive industry. As a result the Bureau can do little of direct interest to the automotive industry with its excellent facilities aside from conducting tests for other Government departments whose appropriations happen to be devoted to such work. This is a reproach upon the automotive industry, for it must be evident to any who acquaint themselves with the need for research along many lines, as indicated by the articles on this subject on foregoing pages of this issue, that there is crying need for light on many important subjects which the Bureau is well equipped to handle. It is to be hoped that another year the industry will co-operate closely with the Bureau in formulating a program of research into the most pressing problems before the industry, and then see that Congress provides the funds necessary to carry it through.

Popularizing Air Travel

THE State, shipping and banking interests are lending powerful support to German aviation, but not content with these subsidies the air transport firms have decided to charge for a journey no more than that charged for first class passage on the railroads. This is being done with the idea of attracting as many people as possible to air routes during the summer.

This would seem to be a recognition that although subsidies were necessary they could not take the place of a universal public opinion favorable to this mode of travel.

Thanks to pioneering spirit and perseverance, progress in aviation is maintained in this country. But this progress might be more rapid if dormant public interest were aroused.

Popularizing air travel, by proof of its practicability and regularity of service, has value in awakening the public and securing the necessary financial backing.

Research, Pure and Impure

THERE is, especially in scientific circles, a distinction between so-called "pure" research and experimental work aiming at some specific development, sometimes termed commercial research. The scientist often pursues experimental work with a view to establishing basic facts regarding some natural phenomena, the governing laws of which have never been established or are not known within the desired limits of accuracy. Frequently such work is done for the mere love of adding new facts to the present sum of human knowledge and with no thought or desire for any pecuniary reward which may result from the commercial application of the information thus made available. The application of existing knowledge to the development of a commercial article often involves extensive tests and laborious investigation both in the laboratory and under service conditions. Such work is frequently referred to as research, but is not such in a narrow interpretation of the term, though it may be quite as commendable and perhaps even more useful to society as a whole.

Quite often commercial development requires careful and extensive research before the basic facts upon which success is dependent are obtained. The two are, in fact, so closely associated that it is not always easy to establish a line of demarcation, especially since the same methods and apparatus used in research work are often employed in commercial testing. This being the case, the Research Number of AUTOMOTIVE INDUSTRIES deals with both "pure" research and development work and has not sought to make a distinction between the two, although we appreciate that such a distinction can be properly made in some cases.

It is doubtless a good thing from many standpoints that passenger car development, in particular, and other lines of automotive development to a less degree are becoming more settled, that less radical changes are to be noted from year to year. It should not be thought, however, that we have approached, much less arrived, at perfection. Many improvements can and must be made. The industry should encourage them and give hearty support to the research work out of which they will come.

May Production Sets New Record!

252,000 Vehicles Output for Month

Exceeds Best Previous Month by 32,000 and May, 1921, by 53 Per Cent

By JAMES DALTON

NEW YORK, June 7.—May was the biggest production month in the history of the automotive industry.

The output of passenger cars and trucks, based upon reports to the National Automobile Chamber of Commerce, was 252,000.

The best previous month on record was March, 1920, when production is estimated to have been 220,000.

Production in April was 218,456.

While shipping figures supplied the N. A. C. C. are only about 90 per cent complete, the final total is likely to be larger than the estimate of 252,000 rather than smaller.

May production showed an increase of 53 per cent over May, 1921, and 15 per cent over April, 1922. Output in May, last year, increased 4 per cent over April.

Carload shipments for May were 33,810, as compared with 30,200 in April and 27,380 in March. The highest previous mark reached by carload shipments was March, 1920, with 29,236.

Cars driven away from the factory in May numbered 21,710, as compared with 22,500 in April and 15,800 in March. Driveaways in May, 1920, numbered 74,286, but carload shipments reached only 21,977.

Boat shipments in May, which numbered 7220, were the third largest on record, having been exceeded only by June and July, 1920, when they numbered 8350 and 8702, respectively.

June Opens Well

June opens with every promise of closely approaching the May mark. There is no noticeable diminution in the volume of orders. Sales at retail in virtually all parts of the country are gratifying alike to manufacturers and dealers. Rapidly improving conditions in the South and the prospect of an early opening of the real buying season in the agricultural sections of the Middle West offer much encouragement. These and

(*Continued on page* 1305)

Business in Brief

NEW YORK, June 5—Continued improvement in business and industry has been reported for the past week. Manufacturing in general is better than at any time since the fall of 1920. The words "poor" and "slow" have practically disappeared from trade and industrial reports.

Except for cotton, crop reports are good. Winter and spring wheat are leading. Better weather and crop reports are responsible for much of the improvement in trade in the West.

The iron and steel industry continues to gain, and operations for the industry as a whole are at about 75 per cent of capacity.

Record building operations are under way in Chicago and permits issued in May called for an expenditure of $27,000,000.

Leading mail order houses report that business in May increased 13.2 per cent over the same month in 1921, the first substantial gain in nearly two years.

A decided turn for the better in the St. Louis territory is reported by the Federal Reserve Bank. The grain areas appear to be making the most notable progress, although all sections of the district have participated in the improvement.

The report of the United States Employment Service for May "clearly emphasizes the fact that business depression is behind us," and that "June will accentuate the upward movement." May brought gains in employment in practically all industries.

Price strength in textiles apparently had aided jobbing distribution.

Stocks are irregular, bonds firm with all Liberty issues at par, and sterling has reached a new high mark.

Bank clearings for the week ending June 1 aggregated $5,980,599,000, a loss of 12.8 per cent from the previous week with a gain of 3.7 per cent over the same week last year.

114,325 PERSONS BUILD ROADS

WASHINGTON, June 3—Persons engaged in highway road building work in the United States now number 114,325, of which 10,483 are automotive and chemical engineers.

Plan Would Put Nash Closer to Lafayette

Latter Company to Be Reorganized with New Capital Exceeding Old

NEW YORK, June 5—A reorganization of the Lafayette Motors Co. under the direct control of the Nash Motors Co. will be voted upon by the stockholders of the former at a special meeting to be held at the Hotel Belmont in this city on June 20. This plan was decided upon soon after the abandonment of the contemplated merger with Pierce-Arrow.

Stockholders will be asked to authorize the sale of all property to the Lafayette Motors Corp., a Maryland corporation. The new company, which will be under the same management as the Lafayette Motors Co., will have a capital of $3,000,000 in 7 per cent first preferred stock of $100 par value; $4,000,000 in 7 per cent second preferred of $100 par value and 30,000 shares of common of no par value. This will exceed by $2,000,000 the capitalization of the old company, but the directors feel that the $2,000,000 additional capital is required.

Provides for Stock Purchase

Under the plan every holder of two shares of preferred stock and every holder of four shares of common stock of the old company may subscribe for a block of one share of first preferred and one share of common of the new corporation at $101 a block.

The Nash Motors Co. will subscribe for the full amount of both preferred and common of the new corporation, to which it is entitled as a stockholder in the Lafayette company. This amount will approximate 8500 shares of each. If the subscription for first preferred and common, including that of the Nash company, should aggregate less than 20,000 shares of each, the Nash company also will take at the subscription prices named such additional amounts of each as may be necessary to bring the total subscriptions up to 20,000 shares of each class.

Balance Sheet of March 31

The Nash company has advanced the Lafayette Motors Co. approximately $500,000 in addition to endorsing bank loans of about $1,000,000. Because of this assistance, about 80 per cent of the common stock of the original Lafayette company was transferred to Nash.

A Lafayette balance sheet as of March 31 last shows the following assets: cash, $206,350; accounts receivable, $82,578; merchandise, $612,808; prepaid expenses, $9,459; land, building and equipment, $1,558,967, making a total of $2,470,162.

(*Continued on page* 1301)

Plants Aim at May Marks for June

Demand by Dealers Forcing Big Output

Some Factories Placing Commitments for Parts 60 Days Ahead on May Basis

By D. M. McDONALD

DETROIT, June 6—June production in the Detroit district will continue at the same forced rate maintained in May which resulted in one of the largest months, if not the largest, the district ever has known. In practically every factory new daily high marks were set during the month and these marks have been fixed as the schedules at which the companies will aim in their production for June.

Executives in most plants declare that from a production standpoint, May has not been excelled by any month since the industry was established. Higher prices in the past, it is declared, may have brought the gross value of cars produced in other months higher and shipments may have been heavier in other months owing to the accumulation of cars in storage, but as a production month May, 1922, should take first rank.

Plants Absorbing Help

Days in which the high marks were fixed were largely the result of favorable manufacturing circumstances, but nevertheless they show the forced pace at which the factories are producing and will be repeated many times when the same favorable circumstances combine. June will be every bit as rushed as May, executives declare, and a number of companies are placing commitments for parts for two months ahead on the same basis as in May.

Factories are steadily absorbing help and companies which were considered fully staffed are making additions ranging as high as 20 daily, as skilled help arrives from other industrial centers. Material deliveries are far from regular, but better than in the early days of the rush. Scarcity of labor and difficulty in getting steel is blamed for failures in meeting requisitions.

There is no question that distributors and dealers are hounding factories for cars. There isn't a factory in the district that doesn't daily receive distributors from distant points, wires and telephone calls, seeking consideration in getting cars through. This has resulted in cancellation of some orders from buyers who would not wait, but what one company loses another gains.

HOW BIG PLANTS WERE WORKING AT END OF MAY

Ford on a 4300 daily basis.
Chevrolet, 1200 daily basis.
Dodge Brothers, 600 daily basis.
Maxwell, 400 daily basis.
Buick, 400 daily basis.
Durant (Lansing), 100 daily basis.
Studebaker (all plants), 440 daily basis.
Hudson-Essex (both makes), 275 daily basis.
Paige-Jewett (both makes), 160 daily basis.
Cadillac, 125 daily basis.

Factory executives declare that extreme delays in making deliveries is only true of certain models, and that with most models the delay is only from 10 to 15 days. This, however, shows that the factories are at least that far behind on shipments and is a clear indication that there is no stocking. Many leading executives, in one case the president of the company, have become stock chasers in order to get their material with the least possible delay.

Orders for Ford coupes are being taken on a six weeks' basis in Detroit. Closed cars in other lines are being bought, subject to from four to seven weeks' delay. Total Ford production is now on a basis of about 4300 daily. The June schedule calls for 135,000 cars, trucks and tractors, of which tractors and trucks will total about 20,000. May production approximated the 120,000 figure fixed, final figures not being complete. This, executives declared, was the best month the company has had.

Two Months' Schedule Arranged

Dodge Brothers' business continues on the 600 daily basis effective now for two months and the sales department anticipates this volume will be continued throughout the year. Maxwell has increased its daily schedule to 400 cars and now has two assembly lines in complete operation. Durant at Lansing has reached a volume of 100 daily and is working to increase this output.

Hupmobile built and shipped 3662 cars in May, a slight decrease in shipments under April but a larger production volume. June production will be increased. Hudson-Essex operated in May on a schedule of 275 daily and will continue this rate during June with increases if possible. Earl motors has reached a

(*Continued on page* 1305)

Conservatism Marks Wisconsin Activity

June, However, Will Show Schedules in Excess of Those for May

MILWAUKEE, June 5—Production of automotive parts and equipment in Milwaukee during May reached the highest point known since the early part of the summer of 1920, and June schedules will be even larger, since manufacturers and jobbers have increased their specifications of delivery since last month. It is interesting to note that while the call for car manufacturers' equipment was the first to reach large proportions, the demand for equipment marketed through the jobbing trade has risen rapidly.

Want Ads Show Conditions

Those who find it necessary to seek substantial evidence of the activity which the automotive industries here have reached need but scan the want ad columns of the daily papers. The A. O. Smith Corp. is advertising for men for night work for press and drill press operation, grinders, electric welders and laborers. The Milwaukee Ford plant wants top builders and upholsterers. Numerous other prominent concerns want men both for day and night shifts.

The majority of shops have now been able to bring forces to normal for day work. As yet many have not found it necessary to put on night shifts, although in some cases it is a fact that while orders might require the double-shift operations, conservatism is being exercised in production as well as purchase of materials lest an over-balance result.

Caution is discernable in all divisions of the industry, and this probably is one reason why the upward movement of automotive activity here and elsewhere has been substantial. It has been at the same time spectacular, yet not to the same degree that it might have been had there been no remembrance of the period which not long ago ended.

No Saturation Evident

Despite the fact that May sales, added to those of April, reached such proportions that some believe the sources of current demand must be near exhaustion, dealers say their prospect files indicate that the remarkable buying movement of the last ninety days is likely to be duplicated in the next three months.

One of the striking features of retail trade which has been present since the buying movement set in, is that dealers are meeting less pressure for price or equipment concessions than was the rule in former years.

Two Companies Join Truck Merger Plan

Selden and Atlas First to Become Members of Industrial Motors Corp.

NEW YORK, June 5—Another ambitious merger plan has been launched under the name of the Industrial Motors Corp. It will bring together at the beginning the Selden Truck Co. of Rochester and the Atlas Truck Co. of York, Pa., which is a subsidiary of the Martin-Parry Corp.

It is understood that this is merely a beginning and that the new corporation ultimately will control half a dozen or more truck and parts companies. One of these undoubtedly will be the Martin-Parry Corp. with plants at York, Pa., and Indianapolis, Ind., manufacturers and distributors of bodies for commercial vehicles.

Watson Heads Committee

The most prominent figure in the plan is John J. Watson, Jr., who is chairman of the committee working out the details. He is president of the Lee Tire & Rubber Corp. and of the Atlas Truck Corp., as well as one of the largest stockholders of the Martin-Parry Corp. Other members of the committee are George C. Gordon, president of the Selden; Frederick M. Small, president of the Martin-Parry Corp.; Robert H. Salmons and Reeve Schley, vice-presidents of the Chase National Bank.

No companies except those making gasoline trucks and accessories will be included in the merger, and no fancy prices will be paid to bring factories in. Reports that the Lee Tire & Rubber Co. will be one of the units have not been confirmed.

The present capitalization of the Selden Truck Co. is $1,000,000 in 8 per cent cumulative first preferred, $300,000 in 10 per cent cumulative second preferred, each of which has a par value of $100, and 30,000 shares of common of no par value.

The Atlas Truck Corp. took over the entire truck body business of the Martin-Parry Corp. in 1920 upon payment of 25,000 shares of its stock plus $250,000 in cash. It has outstanding also 35,000 shares which were sold at $15 a share with preferential subscription opportunity given the Martin-Parry stockholders.

Chase Prominent in Industry

Whether or not there is any special significance in the connection of the Chase bank with the merger, has not been disclosed. Representatives of the bank are included in the directorates of the Martin-Parry Corp. as well as of the Atlas company. The Chase bank also played an important part in the organization of the American Motor Body Co., which was organized in 1920 to take over the Hale & Kilburn Corp. and the Wadsworth Manufacturing Co. of Detroit. The American Motor Body Co. is controlled by the American Can Co. and the Hale & Kilburn Corp. Before its acquisition by the new company, A. J. Brosseau, president of Mack Trucks, Inc., was one of the directors of the Hale & Kilburn Corp. The Chase bank also is represented on the board of the White Co. of Cleveland and was interested in the reorganization of the Bethlehem Motors Corp.

The plan of the promoters is to put forward a specialized motor truck composed chiefly of standard parts now widely recognized. The grouping together of several manufacturers of trucks of this type will permit the greatest economy in the purchase of raw materials and supplies, lower the cost of production and greatly increase efficiency in merchandising and distribution, according to those backing the plan.

The Industrial Motors Corp., incorporated in Delaware, will have an authorized capital of 1,000,000 shares of no par value. Stockholders in the Selden and Atlas companies will get shares of the new company in exchange for those they now own on the following basis:

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DEALERS ANTICIPATE GOOD FARM BUSINESS

By WALTER L. DALY

Vice-President and Sales Manager, Columbia Motors Co.

DETROIT, June 6 — Though there is reason to expect that business will dip in the summer months, there is no reason to expect that it will fall off considerably at any time in the balance of the year. Dealers in the rural districts are confident of a large sale to farmers beginning in the next few months, and they have contracted for heavy shipments of cars.

This rural business will be important to the industry in that it will have a steadying effect upon the dealers in those sections who have already undergone two poor years. If this buying were not to materialize, there would be some forecast of it in the attitude of the dealers. They are sitting firm, however, and preparing to stage their comeback as soon as the crop conditions are safely established.

Closed cars are becoming more and more popular all the time with all classes of automobile owners. Even in the smaller villages and rural comunities the closed car is finding a steadily growing following, and this business will be increased as road improvements are carried out.

The closed car is most popular where driving conditions are best. The use of closed cars increases in every district as its highways are made better.

Legge Is Appointed New Harvester Head

Harold F. McCormick Steps Out and Becomes Chairman of Executive Committee

CHICAGO, June 3—Upon the retirement of Harold F. McCormick from the presidency of the International Harvester Co. yesterday, Alexander Legge, vice-president and general manager, was elected to the presidency by the board of directors. McCormick, whose retirement was voluntary, was elected chairman of a newly created executive committee of the board of directors.

Legge has been with the company for thirty years, having started as a collector for the Omaha branch of the old McCormick Harvester Co., which was later absorbed by the International. Later Legge became manager of the company's branch at Council Bluffs, Iowa, and when Harold F. McCormick as a young college graduate started out to learn the business he was sent to Council Bluffs. There he became closely associated with Legge. Shortly after McCormick returned to Chicago in 1897 Legge was brought here and made manager of the collection department.

Had Charge of Sales

For a number of years Legge has been in charge of the sales of the company, and probably will continue to exercise close supervision over that department. His election to the presidency does not mean any change in administrative policy, for he has been virtually the operating head of the company for a number of years. McCormick issued a statement saying that as chairman of the executive committee he did not contemplate any diminution in his interest in or service to the company.

The directors were given an encouraging report of the company's business. Nearly all of the tractors which have been an inventory burden for two years were reported sold, although at some loss. Prospects were said to indicate a large volume of business and satisfactory earnings for next year.

Other members of the new executive committee are: Cyrus H. McCormick, chairman of the board of directors; Alexander Legge, William D. McHugh, general counsel, and John P. Wilson, consulting counsel.

TAKING STEVENS INVENTORY

SPRINGFIELD, MASS., June 5—Receivers for Stevens-Duryea, Inc., will finish taking the inventory of the company's property in about a week, it was said to-day by Harry G. Fisk, who with Frank H. Shaw of Chicago was named receiver. Promptly thereafter, it was stated, a report of the state of the company's affairs will be made to the Superior Court. Orders at the factory are said to assure good business for the summer.

Overland Suit Filed by Willys Receivers

Claim of More Than $5,000,000 Met by Counter-Claim for $5,107,766

TOLEDO, June 5—Federal Judge Killits has set June 19 as the day for a conference here of all persons interested in the litigation by which the receivers for the Willys Corp. hope to establish claims for more than $5,000,000 against the Willys-Overland Co. as well as a counterclaim of the Overland company against the corporation for $5,107,766 for materials supplied the Electric Auto-Lite Corp.

Negotiations for a settlement out of court have been under way for some time, but were abandoned a few days ago. It is estimated that the claims of the corporation are considerably in excess of those filed by the Overland company. Judge Killits will attempt to bring about an amicable adjustment.

Counsel Outlines Claims

George T. Hahn, special counsel for Frank P. Kennison and Francis G. Caffey, receivers of the Willys Corp. has filed an intervening petition in the case of the Ohio Savings Bank & Trust Co. against the Willys Corp. In this petition he outlines the claims against the Willys-Overland Co.

When the capital of the Willys-Overland Co. was increased by $25,000,000 on May 6, 1920, it is claimed that Willys Corp. as a stockholder waived its right to subscribe to this new common stock. Later 329,866 shares of common stock were issued by the Willys-Overland Co. for the Willys Corp. in the name of "J. R. Harbeck, syndicate manager." At this time a majority of the directors of the Willys Corp. also were directors of the Overland Co. and for this reason a technical fraud in the procedure is claimed. The price paid was far in excess of market value, the petition alleges. Return of the subscription price of this stock is asked by the receivers.

Chrysler Six Mentioned

The other claim arises from a contract between the two companies whereby the Overland was to perfect a light six cylinder car to be known as the Chrysler six and the Willys Corp. was to manufacture and market the car.

The petition alleges the representations made by the Willys-Overland Co. were untrue and the car was unfit for manufacture or sale. The plant at Elizabeth was built for manufacture of this car and tools and equipment were bought for that purpose. The receivers want an accounting of damages thus incurred and judgment for them.

Judgment for $136,637.71 is also asked on account of indebtedness.

The petition states the corporation at one time offered to return its common stock shares for the return of the purchase price by the Overland company, but the latter refused.

Tracy, Chapman and Welles, attorneys for Clement O. Miniger, in the purchase of the Electric Auto-Lite division of the Willys Corp., have incorporated the Electric Auto-Lite Co. in Ohio with a capital of 500 shares of common stock of no par value. The attorneys said the incorporation was only nominal, but that it might be used in case the properties were sold at the sale set for next Wednesday. It was also said it might be a sales company. Delay in incorporating such a company may have been one of the causes for Miniger's unreadiness to bid last Monday.

CONGRESS MAY FATHER TRANSPORT INSTITUTE

WASHINGTON, June 5—Plans are under way to have Congress father a novel school of inquiry to be known as the National Transportation Institute, to deal primarily with transportation problems, but in an entirely different way from the methods pursued by any present Federal agency. It is to be conducted somewhat along the lines of the Rockefeller Foundation.

The Joint Commission of Agricultural Inquiry is sponsor for the school. It proposes the establishment of a private research and educational institution under disinterested auspices to promote education in the principles, operation and practices incident to transportation.

Stockholders Protesting Avalon Sale for $28,500

AKRON, June 5—Stockholders of the defunct Avalon Rubber Co. of Barberton have filed with Judge C. D. Westenhaver of the United States district court at Cleveland a petition protesting the order of Bankruptcy Referee Harry L. Snyder of Akron, in selling the Avalon plant to private Akron interests for $28,500, over the stockholders' joint bid of $30,000. The cash bid was made by a syndicate represented by Clyde Alvis, which has announced it will convert the Avalon plant into a factory for electrical devices and radiophone equipment.

The stockholders' bid was $10,000 cash and $20,000 in notes, but Snyder accepted the cash bid in preference. The company has been in receivership for several months with Ray F. Hamlin of Akron as receiver and trustee in bankruptcy. Its liabilities are about $35,000.

COMPLETING EXPORT MANUAL

WASHINGTON, June 5—The Foreign Trade Automobile Export manual, being prepared by the National Automobile Chamber of Commerce, through its special representative, L. E. Warford, is approximately three-fourths completed.

Harley Bankruptcy Receivers Named

Court Restrains Hendee from Foreclosing—Long Litigation Forecast

SPRINGFIELD, MASS., June 6—An involuntary petition in bankruptcy has been filed against the Harley Co. as the latest twist in the chain of entanglements begun after the purchase of this concern from the Hendee Manufacturing Co. for $1,100,000 several months ago.

Samuel M. Green and George A. Bacon, both of Springfield, have been appointed receivers in bankruptcy. At the same time the United States district court issued an order restraining the Hendee company from foreclosing on the Harley property because of an alleged default on the mortgage. The court denied a request that John D. Stephens, assistant treasurer of the Hendee company, be named as one of the receivers. It is expected that the receivers' investigation will be completed within two weeks.

Wished to Prevent Foreclosure

The bankruptcy petition followed upon a refusal of the United States District court on June 1 to grant a receivership for the company, sought by a group of stockholders as a means of preventing foreclosure by the Hendee company of its mortgage for $725,000.

It was alleged the concern was solvent but did not possess ready means with which to pay bills. The court denied the petition of Frank D. Zell of Pennsylvania for a receiver on a ruling that it could not legally be initiated by a stockholder, and further than this the merits of the sale were not considered. Bankruptcy proceedings are brought on petition of four creditors with claims totaling $1,917, most of which is itemized as wages due employees of the company.

Admits Inability to Pay

Attached to the petition when filed with the United States District Court in Boston was a statement by President A. W. Morris that at a stockholders' meeting June 1 the company admitted its inability to pay its debts and its willingness to be adjudged in bankruptcy. In answer to an inquiry, Morris said that he believed the Harley Co.'s affairs would be in litigation for some time.

MAY INVESTIGATE CURTIS

LITTLE ROCK, June 5—Suit has been filed in chancery court which opens the way to judicial investigation of the Curtis Motor Car Co., a concern which was organized and promoted locally in the autumn of 1919, and which went into the hands of a receiver last April, with reported assets of $87. Residents of Little Rock and other Arkansas communities are said to have invested more than $100,000 in stock in the concern.

Durant Would Build Star at Elizabeth

Likely to Get Plant for Approximately $3,000,000 at Receivers Sale

NEW YORK, June 8—Durant Motors, Inc., undoubtedly will purchase the huge new plant of the Willys Corp. at Elizabeth, N. J., when it is offered at receiver's sale to-morrow, June 9. Unless there are unexpected developments, Durant will be the only bidder. His offer will approximate $3,000,000, and he asserts positively that if anyone attempts to run up the price beyond the sum he has bid he will drop out. The construction of the plant cost about $10,000,000.

If Durant's bid is accepted and confirmed by the court, he will use the plant exclusively for the manufacture of the new Star car which was designed to compete with Ford. The Long Island City plant will continue in operation to turn out the Durant line.

The schedule for the various Durant cars for 1923 calls for a minimum of 120,000 and a maximum of 200,000. The Oakland, Cal., factory will be ready for production in 30 or 40 days. It will contain 300,000 sq. ft. of floor space and will have a capacity of 50,000 cars, of which 40,000 will be Stars.

If the demand for the Star develops as rapidly as is expected, most of the factory space in the Elizabeth plant, which covers 2,100,000 sq. ft., will be required for the assembling of the new line.

Must Deposit $200,000

The court has directed that $200,000 must be deposited before the bidding begins on parcel one, which includes the land, buildings and fixtures comprising the main plant. This is all of the property in which Durant is interested.

A separate bid will be asked for approximately $2,000,000 worth of machinery and tools which were installed in the factory before the Willys Corp. was thrown into a receivership.

So far as can be learned there is no basis for reports that Durant might ask the parts makers who will supply the essential units for the Star to establish branch plants in the Elizabeth factory in the interest of economy.

A. M. A. COMMITTEE PERSONNEL

CHICAGO, June 5—The committee representing the delegates who withdrew from the American Automobile Association at St. Louis, May 20, which has issued a call for all automobile clubs interested to meet at the Sherman Hotel here, June 19 and 20, to perfect an organization of the American Motorists' Association, is composed of Fred H. Caley of Cleveland, Charles C. Jones, Columbus; N. E. Noblet, Indianapolis; Richard H. Lee, Chicago; Henry Paulman, Chicago; B. H. Hagerman, Kansas City; Eugene Stuart, Louisville; H. R. Keltig, Louisville; Ewing S. Mosely, Dallas; G. E. Gillespie, Lincoln; W. Q. Winship, St. Paul; M. P. Lawler, St. Joseph, Mo.; A. G. Lupton, Hartford City, Ind., and Walter D. Meals, Cleveland.

MARYLAND COLLECTS CENT GASOLINE TAX

BALTIMORE, June 2 — The State of Maryland added to-day to the high cost of gasoline when it began collection of a tax of one cent a gallon on gasoline used in motor vehicles. The revenue will be used to reduce a long-standing deficit of $1,000,000 in the maintenance fund of the State Roads Commission.

The tax expires on Dec. 31, 1923, but on the day following another tax of two cents a gallon becomes effective, the proceeds to be applied to a reduction in the fees for the registration of automobiles.

Stewart Makes Changes in Its Capacity Ratings

BUFFALO, June 5—The Stewart Motor Corp. has changed the wheelbase on the Utility Wagon from 123 to 128 in. and the tire size all around has been increased from 32 x 4½ to 34 x 4½.

A slight change has been made in the capacity ratings on other Stewart trucks as follows:

Model	Capacity	Price
Utility Wagon	500 to 2,500 lbs.	$1,245
15	1¼ to 1½-ton	1,445
9	1½ to 2-ton	1,790
7	2 to 2½-ton	2,190
7X	2½ to 3-ton	2,390
10	3½ to 4-ton	3,190
10X	3½ to 4-ton	3,190

Trask Detroit Steamer Now Being Manufactured

DETROIT, June 6—Manufacture of the Trask Detroit Steamer has been started in the plant of the Schlieder Manufacturing Co., this city, manufacturer of valves.

The first of the product, a phaeton model, priced at $1,585, is now being exhibited in the lobby of the Detroit Board of Commerce. O. C. Trask, president of the Detroit Steam Motor Corp. is in charge of manufacturing at the Schlieder plant.

The car has a 115 in. wheelbase and weighs 2000 lbs. The two cylinder engine is directly connected with the rear axle. It is declared to develop the equivalent of 45-50 horsepower. Control of the car is by the throttle on the steering post. A distributor organization is being developed. Dominion Steam Motors has been formed in Windsor to handle the sale of the car in Canada.

Goodyear Makes Bus With Eight Wheels

Is Development of Present Six-Wheeled Vehicle—Same Chassis Used

AKRON, June 5—An eight wheel passenger bus—an entirely new departure in motor vehicle design—is being developed by the Goodyear Tire & Rubber Co. of Akron, which two years ago pioneered in the successful development and practical demonstration of the six wheel chassis for both truck and passenger buses.

The first six wheel passenger bus perfected by Goodyear engineers is being remodeled and made into an eight-wheeled bus, with four wheels in the rear and four in front. It will carry a street car body of the Peter Witt type, with pay-enter folding doors and collapsible steps, and seats and standing room for 55 passengers.

The new eight wheeler will have practically the same chassis and wheelbase as the six wheeled vehicle, with a wheelbase of 180 in. from the center between the front wheels to the center between the rear wheels.

Goodyear engineers have perfected a system whereby the big bus can be steered by all four front wheels operated with a single steering wheel. The front and rear wheels of the front truck have been arranged with different radius lengths so as to permit proper tracking when the vehicle is turned and the wheels are at an angle to the chassis.

Litchfield Worked Out Plan

His conviction that the ultimate motor vehicle would be multiple wheeled, taking the same evolution as the freight car, led to P. W. Litchfield's working out plans for the first six wheeled motor vehicles ever put into practical use in America several years ago. Litchfield is vice-president and factory manager of the Goodyear company.

Six wheeled trucks and buses now are being used regularly in Akron. They have proved to have easier riding qualities, a lower center of gravity and better traction, while tire equipment is less expensive than for a conventional four-wheeled truck with larger wheels. The new eight wheeler is expected to make its debut within a month or so.

PILOT HAS SPORTSTER

RICHMOND, IND., June 6—The Pilot Motor Car Co. has a sportster model, deliveries of which began on June 1. It is of the four-passenger type and carries barrel type headlamps, with cowl lamps to match. The runningboards are displaced by aluminum side steps with individual fenders, and there is an aluminum trunk rack with protecting bars on the back of the body and other specially built features not heretofore used by the Pilot organization.

Akron Stills Strife by Wage Adjustment

Labor Restless Under Improved Conditions—Makers Bid Against Each Other

AKRON, June 5—Labor strife, cropping out among rubber workers in the Akron tire factories and apparently conducted by the steady climb back to prosperity of the tire industry and the increasing heavy demand for labor upon the part of the larger tire concerns, has forced wage adjustments in most of Akron's factories within the past ten days.

The Firestone Tire & Rubber Co., on top of a wage increase for all factory employees ranging from 9 to 12 per cent, has increased the salaries of all office employees by 10 per cent. In the face of the Firestone wage revision, however, a small group of workmen walked out, contending that if any increase be made at all, it should be more than that given. The dissension was confined to a few minor departments, however, and the demand of the men remained unheeded. Some of those who walked out have resumed work, while others are seeking jobs in other factories.

Goodrich Reduces Shifts

The B. F. Goodrich Co., at least temporarily, has salved a feeling of dissension breaking through the service in several departments, and has made adjustments by reducing shifts from ten to eight hours each and giving the men nearly the equivalent of ten hours pay for eight hours work. The new scale at Goodrich under this arrangement is reported to be 77½ cents an hour for skilled tire builders. The company in the negotiations offered 71 cents, countering a demand from employees for 80 cents, the comprise being reached on 77½ cents.

The Miller Rubber Co. has quietly made adjustments of wages wherever necessary in its factory, without enforcing any set scale of increase or without making any public announcement of what revisions are known to have been made. The Mason Tire & Rubber Co. at Kent has had some trouble with a group of its men, but now reports labor conditions normal.

The Goodyear Tire & Rubber Co. so far seems to have been free from any serious dissension or wage strife, although it is a matter of conjecture in rubber circles that practically all the tire companies, both large and small, sooner or later will have to follow the Firestone lead of announcing flat increases to their men.

Faced with Labor Shortage

Where Akron a month ago had a labor surplus, the Rubber City to-day is faced by an absolute labor shortage along all lines. Common labor has become independent, in fact, and men are refusing work at 45 cents an hour, whereas a month ago they were glad to get it at 35 and 40 cents an hour.

Rubber companies have apparently revived the old tactics, laid upon the shelf by amicable agreement during the slump era, and are bidding against each other for men, advertising in other cities and painting jobs here as attractively as possible.

The mad pace in tire production continues unabated. Firestone is hitting 25,000 tires a day, Goodrich 16,000 and Goodyear is striving to get enough men to attain a production ticket calling for 26,000 casings daily. Goodyear is reported to have almost completely exhausted its finished goods inventories, in order to fill rush orders, and it is admitted that if enough men are available the company will jump to 29,000 or 30,000 tires a day, long enough to catch up with orders and to build up again a sufficient reserve for the future.

Timken Bearing Raises Wages

CANTON, OHIO, June 5—Wages of all shop employees of the Timken Roller Bearing Co. have been advanced 10 per cent. Salaries of other employees have been adjusted to make the pay the same as it was prior to Sept. 1, 1921, when wages were cut.

Stockholders Provide New Oshkosh Capital

OSHKOSH, WIS., June 5—By unanimous vote of stockholders, an amended plan for refinancing the Oshkosh Motor Truck Co., Oshkosh, Wis., has been put into effect. The sum of $76,000 has been provided which will make possible the liquidation of a considerable portion of the indebtedness and such an extension of time on the balance as will insure the safety of the company.

The amount of $43,000 has been subscribed by stockholders, and trucks on hand and in process when the business slump overtook the truck industry to the amount of $33,000 have been sold. The reorganization of the Oshkosh Motor Truck Sales Co. recently enabled the company to market considerable of the surplus, the remainder of which is steadily being absorbed, enabling the company to resume output on a fair scale, with prospects of a nearly normal schedule of production within a relatively short time.

Investment Company Holds Various Kelsey Interests

DETROIT, June 5—The John Kelsey Investment Co. has been formed in this city with a capitalization of $1,500,000, 15,000 shares at $100 a share, to consolidate the different business enterprises of John Kelsey under one head.

Stockholders in the new company are John Kelsey, 14,998 shares; George Kennedy one share and William Duncharme one share. Kelsey said it was not the intention of the investment companies to engage in any new businesses, but to simplify the management of the existing companies. The Kelsey Wheel Co., Inc., is the principal of the Kelsey holdings.

Detroit Employment 50,000 Above 1921

Complete Recovery of Industry Seen by Government in Survey for May

WASHINGTON, June 4—Measured in terms of employment, the automotive industry has completely recuperated, according to the industrial survey for the month of May conducted by the United States Employment Service.

The automotive industry again registered first in the percentage over employment in April as the gain for this industrial classification amounted to 11.2 per cent, with railroad repair shops the nearest competitor in employment gains, having an average of 4.6 per cent. The actual increase for fourteen industries showed 3.2 per cent in the number on their payrolls as compared with April. The increasing activity in the automotive industry has reflected itself in allied industries.

Activity in Indiana

In Indiana, representatives of the Labor Department report that the demand for skilled help in the automobile and accessory lines is so active that certain classes of workers can be supplied only with difficulty. An increased demand for bench men, cabinetmakers and all-around mechanics is apparent. The revival of business has brought an increased demand for office workers and sales people in Indiana.

In Indianapolis, the automotive plants particularly are running at top speed, and a shortage of skilled automotive labor exists. All motor and plow manufacturers are working overtime in South Bend.

Other Industries Stimulated

In its survey of Michigan, the Federal Employment Service says:

"This has been the biggest production month the automotive industry has ever had. The business in sight will keep the plants going at top speed until the middle of July. The automobile activity has also stimulated employment in other industries, such as steel, and including aluminum, cotton fabrics, oil, electrical manufacture, and the numerous parts and accessories."

It is significant to note that in Detroit there are now employed 50,000 more men than during the peak of 1921, and the output for May was even greater than the previous month's increased production. One high-priced motor car company is hiring men at the rate of 120 a day. A year ago this company was operating with a working force of approximately 3300, while to-day there are 7000 on the factory payroll.

At Flint there is a shortage of skilled help in the automotive industry. One motor company is making 100 cars a day, or more than double last year's rate of

(*Continued on page* 1304)

Canada Protesting Increased Taxation

Representatives of A. I. C. Will Make Direct Appeal to Government

TORONTO, June 2—The members of the automotive industry of the Dominion are a unit in protesting against the new ad valorem 5 per cent excise tax on cars priced to dealers at $1,200 and under, and 10 per cent on cars selling to the trade at a price in excess of $1,200.

The Canadian Automobile Association and Ontario Motor League argue that the singling out of the motor car for special imports places it in the same category with candies, intoxicating beverages and tobacco, and is inherently a tax on individual and national efficiency.

Manufacturers to Act

Representatives of the automotive industries of Canada (the N. A. C. C. of the Dominion) have convened in this city purposing to wait on Hon. W. S. Fielding in Ottawa to present their brief against the new excise imposts. To the credit of those whose position is relatively improved by the 5 per cent discrimination against the higher priced makes be it said that they all are joining in the opposition. It is declared generally that the special tax is a breach of the pre-election promise of the premier, Hon. W. L. McKenzie King, that no special taxes would be imposed on motor vehicles in the event of his party sitting in the driver's seat of government.

Budget proposals of automotive interest have been somewhat classified and deprived of much ambiguity. The general sales tax has been increased 50 per cent, or from 4 per cent to 6 per cent on imported cars and from 3 per cent to 4½ per cent on cars of domestic manufacture. The 5 per cent or 10 per cent excise tax, as the case may be, is added to the sales tax and computed on the manufacturers' list price or the duty paid value respectively of Canadian made or imported cars.

Settlers' Effects Free

Under a provision of the budget, tractors selling for $1,400 or less and parts thereof will enter Canada free hereafter by act of Parliament. For some years they have entered duty free by Order-in-Council. The budget also provides similarly that automobiles be permitted to enter duty free valued at $1,000 or under if settler's effects, and up to any value if farmer and settler's effects.

The import tax on gasoline over 0.725 and not exceeding 0.750 gravity has been reduced from 2½ cents to 1 cent a gallon under the general tariff.

The budget further provides that the legislation providing a fixed valuation on imports from countries with depreciated currencies be repealed. This provision will, of course, profit the countries with depreciated currencies, and especially Germany.

While the British preference has been somewhat increased in some textiles it does not affect automotives.

The special tax on motor cars, it should be added, is collected from the Canadian manufacturer or importer at time of shipment or importation and, of course, is passed on to the dealer and in turn to the consumer either as a stated tax or included in the selling price. Most quotations are now "plus tax."

Among the points the A. I. C. will stress are: that the tax is wrong in principle in that it discriminates against one essential industry, that the tax discriminated between members of that industry, and that it will retard the return of development, progress and prosperity at the same time resulting in unemployment.

Racine Horseshoe Tire Completes Organization

RACINE, WIS., June 5—Reorganization of the defunct Racine Auto Tire Co. of Racine, Wis., by a new corporation known as the Racine Horseshoe Tire Co., has been completed by Eastern financial interests which have a working arrangement with the stockholders and Racine and Milwaukee banks. The new officers and directors which have taken over the management are:

President, J. C. Lawrence of S. W. Straus & Co., Chicago; vice-president, O. D. Hollenbeck; secretary and sales manager, L. H. Shepherd; treasurer, Raymond H. Weins, Racine. Lawrence was for eleven years an officer of the B. F. Goodrich Rubber Co., Akron. Hollenbeck is a former Firestone official, and Shepherd is a former Goodrich man.

The board of directors, of which Lawrence is chairman, consists of the following: H. H. Whiteman, fabric manufacturer, Boston; H. J. Lyall, attorney, New York; N. Howard Green, fabric manufacturer, Boston; Francis J. Johnson, banker, Chicago; W. C. Crawford, banker, New York; John W. Bate, financier and manufacturer, Racine; Frederick L. Sivyer, steel foundry owner, Milwaukee; William O. Goodrich, capitalist, Milwaukee.

Ford Shifts Departments to Help Lincoln Factory

DETROIT, June 2—Sales and service offices of the Ford Motor Co. have been moved to the Lincoln Motor Co. plant, and the purchasing department of Lincoln has been moved to the Highland Park plant of the Ford company. The relocation of the departments is declared by executives to be of an experimental nature, and part of the plan is to familiarize the members of the Lincoln departments with Ford policies and methods.

There will be no consolidation of the departments of the two companies, it was declared, as it is the Ford plan to maintain them as two entirely separated divisions, each with its own operating and executive staff.

Boycott Against Bus and Truck Spreads

Starting at Roseville, Cal., Now Reaches to San Francisco—Dealers Aroused

LOS ANGELES, June 6—The activities of employees of the Southern Pacific Railroad in extending their attempts to curtail motor truck shipping are developing. Starting at Roseville, Cal., where the blacklist and "we don't patronize" embargo was placed on motor freight and bus lines, and merchants were petitioned to refuse to handle goods shipped by truck, the movement now has spread to San Francisco.

Under the supervision of the Southern Pacific Good Service League, the Chamber of Commerce and many other organizations have been sent copies of resolutions asking that they patronize the railroads rather than the bus and truck, and that these organizations use their influence to bring about heavier taxes for the highway carriers.

In the preamble to the resolution, the league sets up that the Southern Pacific Railroad is meeting severe competition under unjust conditions from commercial motor trucks and buses; that the railroad pays taxes which are used in part to maintain the highways over which this competition operates; that this continued competition will so impair the revenues of the railroad that its employment of working forces will be curtailed.

League Strikes Snag

The railroad's taxes, the purchases, expenditures, payroll, etc., are set up in detail, and attention is directed to the fact that San Francisco's merchants benefit from these expenditures.

The league struck a snag when these resolutions were addressed to the Motor Car Dealers Association. The association appointed a committee to consult with officials of the railroad to ascertain if they instigated or were a party to the circulation of the petitions. Pacific Coast automobile dealers pay to the railroads about $19,000,000 annually in freight bills, and there is some talk of a plan in retaliation whereby these shippers would discontinue their patronage of Southern Pacific lines.

OPTIMISM AT TRUCK MEETING

PONTIAC, MICH., June 6—Conditions were never so bright for truck business in the retail field, according to thirty sales managers and agents from Boston, Philadelphia, New York and Kansas City districts in convention at the General Motors truck plant here to-day. Universal optimism was revealed in the meeting. Two sales sessions were held. The conference closes to-night. Next Monday and Tuesday the fourth of the convention series will be held at the plant, with men from the South and Southwest, from Atlanta to El Paso in attendance.

Activity in Building Boosts Truck Sales

Passenger Car Business Also Continues Improvement in Southern California

LOS ANGELES, June 3—The rush of automotive buying in southern California continues. When it began in March there were many to predict it could not last long, but it is improving rather than diminishing. The splendid business is being enjoyed not only by the passenger car dealers but exclusive truck merchants are experiencing a big demand as well.

The truck business undoubtedly is based largely on the unprecedented building activity. Los Angeles has been ranking third among all the cities in the United States in building permits. There is not as much road building as in some previous years, but this line is constant on the average. The number of Government and state trucks in use makes comparatively few privately owned trucks in this work.

Statistics just compiled indicate that the number of new passenger cars sold in this part of the state the first four months of the year was 21,651 as compared to 13,843 during the same period in 1921. In Los Angeles alone there have been 10,024 new cars sold in the four months as compared to 5997 one year ago.

Slightly more than one-third of all the new cars sold are Fords. Chevrolet is getting about 15 per cent of the total business. Willys-Knight has shown a gain of 300 per cent. Six cars show fewer sales than last year. In some cases this can be attributed to the fact the factory's financial condition has hurt the confidence of the public in the car.

Plan Would Put Nash Closer to Lafayette

(*Continued from page* 1294)

The liabilities were: notes payable, $1,440,000; accounts payable, $29,191; dealers' deposits, $21,750; accrued liabilities, $56,388, making a total of $1,547,329, leaving the net worth of the company $922,831.

The new corporation has made an offer to purchase all the property and assets of the Lafayette company in consideration of the assumption of all its debts and liabilities and the issuance to the Lafayette company of 40,000 shares aggregating $4,000,000 par value of the second preferred stock of the new corporation. The stock will be distributed share for share to the holders of the preferred stock as a dividend in final liquidation.

The Lafayette Motors Co. was organized in 1919 and erected a modern plant at Mars Hill, a suburb of Indianapolis. It was unfortunate in getting under way just as the business depression began. It sold approximately 1000 cars, but general business conditions were such that its outlay far exceeded cash returns.

Charles W. Nash, president of Nash Motors, has been president of the Lafayette company and a majority of the members of the board of directors have been Nash directors. They included Nash, James J. Starrow of Boston, chairman of the Nash board, and Frederic W. Allen of New York.

Nash will continue to direct the affairs of both companies.

Republic Truck Operates at 50 Per Cent Capacity

DETROIT, June 3—Republic Truck Co. is now producing between 450 and 500 trucks monthly, or at a rate of approximately 50 per cent of the normal capacity of the plant, President F. E. Smith declares. There is little buying of a farmer nature at this time, he said, the bulk of the business being by industrial companies, and originating for the most part in the Eastern section of the country.

Farm buying is expected to start in July and reports from Middle Western sales territories indicate that this will be on a fairly large scale, President Smith said. Most of the Republic business is in the heavier vehicles, but light truck buying is developing. Buying is divided about equally as regards pneumatic and solid tired vehicles, most of the pneumatic being in short wheel-based models.

Output and Shipments of Casings Still Gain

NEW YORK, June 6—Statistics of the rubber industry for the first four months of the year, as compared with the same period in 1921, follow:

PNEUMATIC CASINGS

1921—	Inventory	Production	Shipments
Jan.	5,319,605	703,430	965,417
Feb.	5,193,018	819,892	1,073,756
March	4,597,103	1,163,314	1,614,651
April	4,527,445	1,651,418	1,785,951
1922—			
Jan.	4,174,000	2,055,000	1,597,000
Feb.	4,691,000	2,084,000	1,562,000
March	5,183,286	2,645,790	2,073,963
April	5,464,336	2,401,187	2,086,651

INNER TUBES

1921—	Inventory	Production	Shipments
Jan.	5,586,163	740,824	1,042,617
Feb.	5,415,464	916,627	1,139,881
March	5,044,861	1,346,483	1,643,690
April	4,916,772	1,762,122	1,983,571
1922—			
Jan.	5,247,000	2,343,000	1,890,000
Feb.	6,142,000	2,597,000	1,703,000
March	6,991,118	3,017,511	2,090,737
April	7,230,096	2,650,573	2,329,343

SOLID TIRES

1921—	Inventory	Production	Shipments
Jan.	303,753	21,220	29,116
Feb.	304,374	23,365	29,599
March	283,800	27,710	43,926
April	269,985	28,859	42,080
1922—			
Jan.	182,000	40,000	33,000
Feb.	183,000	39,000	37,000
March	182,197	49,433	48,350
April	173,748	46,664	52,309

"Production" and "Shipments" figures cover the entire month for which each report is made. "Inventory" is reported as of the last day of each month.

"Inventory" includes tires and tubes constituting domestic work in factory and in transit to, or at warehouses, branches (if any), or on possession of dealers on consignment basis, and as a total represents all tires and tube still owned by manufacturers as a domestic stock.

"Shipments" includes only stock forwarded to a purchaser and does not include stock forwarded to a warehouse, branch, or on a consignment basis, or abroad.

Two Companies Join Truck Merger Plan

Selden and Atlas First to Become Members of Industrial Motors Corp.

(*Continued from page* 1296)

One hundred and twenty thousand shares of new stock exchanged, two for one, for 60,000 shares of Atlas; 60,000 shares of new stock exchanged, two for one, for 30,000 common shares of Selden; 24,000 shares of new stock exchanged, eight for one, for 3000 shares of first preferred shares of Selden; 80,000 shares of new stock exchanged, eight for one, for 10,000 shares of second preferred shares of Selden. Of the balance, 20,000 shares are to be issued for promotion.

Spicer-Hydraulic Merger

NEW YORK, June 6—Official confirmation still is lacking of reports of an impending consolidation of the Hydraulic Steel Co. of Cleveland and the Spicer Manufacturing Co. with plants at South Plainfield, N. J., and Pottstown, Pa. J. H. Foster, president of Hydraulic, declared at Cleveland that he deemed it unwise to discuss the subject at this time. C. A. Dana, president of Spicer, has been out of the city, and it was impossible to obtain a statement from him.

A consolidation of the two companies would result in a strong combination. The Hydraulic Steel Co. has as subsidiaries the Cleveland Welding and Manufacturing Co. and the Hydraulic Steel Craft Co., both of Cleveland. Announcement was made last week that it had sold the Canton Sheet Steel Co. to the United Alloy Steel Corp.

The Spicer Manufacturing Co. owns the entire capital stock of the Sheldon Axle & Spring Co. of Wilkes-Barre, Pa., and the Parish Manufacturing Co. of Reading, Pa., and Detroit, as well as the common stock of the Salisbury Axle Co., Inc., with a plant at Jamestown, N. Y.

Capitalization of Companies

The Hydraulic Steel has an authorized capital stock of 500,000 shares of common of no par value and $6,000,000 in 7 per cent cumulative preferred. There are outstanding 225,849 shares of common and all the preferred. Application recently was made to list an additional 150,000 shares on the New York Stock Exchange. It also has outstanding $2,957,500 in 8 per cent 10 year gold notes.

The Spicer Manufacturing Co. has a capitalization of 600,000 shares of no par value common and $10,000,000 in cumulative preferred. It has outstanding 313,757 shares of common and $3,000,000 of preferred. It has a funded debt of $2,400,000 in 6 per cent serial gold notes which were issued to provide in part for the purchase of the Parish and Sheldon axle stock.

Reports that the Detroit Pressed Steel Co. also will consolidate with the Hydraulic have been revived.

Men of the Industry and What They Are Doing

Bartsch Back from Trip

Alfred H. Bartsch, general sales manager of the American Bosch Magneto Corp., has returned for a six weeks' circuit of the eastern and southern states, having visited 33 leading cities in that time. The trip was made for the purpose of investigating general conditions and studying their probable effect on automotive sales during the next six months.

Sam Miles Sails for Home

S. A. (Sam) Miles, show manager of the National Automobile Chamber of Commerce, sailed from Liverpool last Saturday on the Aquitania on his way home with Mrs. Miles after their annual visit to Europe.

Lauer to Run for Congress

Robert M. Lauer, comptroller of the Federal Rubber Co., Cudahy, suburb of Milwaukee, has consented to be a candidate for the Republican nomination for member of Congress from the Fifth Wisconsin district, now represented by W. H. Stafford. This district twice elected Victor L. Berger to a seat in the House which he was denied by a vote of that body.

Lee to Fly to Meeting

Gordon Lee, chief of the automotive division of the Department of Commerce, will fly to the meeting of the Foreign Trade Committee, which will be held in the headquarters of the Motor & Accessory Manufacturers' Association in New York on June 12. This has been made possible through the offer of Major Hickam, chief of the information section of the Air Service.

Hydro Tire Appoints Hedges

William F. Hedges has retired from the tire business in Fort Wayne, Ind., to assume the position of manager of the Middle West States' branch of the Hydro-United Tire Co., located in Chicago. He is well known in the tire world having been identified with the industry since 1913. He has served in all branches of tire sales, promotion and advertising for various rubber companies throughout the country. Associated with Hedges is D. H. Coan, formerly in business in Canton and Fort Wayne.

Figgie Joins Standard Spring

Harry Figgie, formerly in charge of sales for the Perfection Spring Co. of Cleveland, has become associated with the Standard Steel Spring Co., Coraopolis, Pa., in a similar capacity. He is a graduate of Case School of Applied Science and spent a number of years in the shop before taking up the sales end of the spring business. He is a member of the Society of Automotive Engineers, being attached to the Cleveland section.

Kryl and Eichleman Partners

J. M. Kryl, president of the Kryl Bridge & Crane Works of Chicago, and W. H. Eichleman, until recently the chief engineer of the Hamler Boiler & Tank Co. of Chicago, have formed a partnership as steel fabricators. Both men are graduate engineers, and they now have facilities for handling oil and wood tanks, process kettles, ornamental iron and structural steel.

Serra Lima Visiting U. S.

Among the passengers on the "American Legion" of the Munson line arriving in New York on May 29 was Frederico A. Serra Lima, South American automobile racer. Serra Lima holds the championship for 200 and 350 mile distances in South America, having won the former against 32 cars and the latter against 28. He represents the Hudson Motor Car Co. in Buenos Aires and also Buxton Guilayu & Co. of England.

Vacuumeter Appoints Stone

L. Z. Stone has been appointed director and sales promotion manager of the Vacuumeter Manufacturing Co., Cleveland. Stone has specialized in the automotive sales field, having been associated with the Diamond Rubber Co. and the Goodyear Tire & Rubber Co. Lately he has been connected with advertising agencies, in charge of automobile and accessory accounts.

Jaeger Recuperates in Florida

Harry S. Jaeger has given up active work for the time being and is recuperating at Fort Myers, Fla. He was at one time in the sales department of the old E. R. Thomas Motor Co., then in sales and purchase with the Thomas Motor Car Co. Later he became service manager of the Atterbury Motor Truck Co. and salesman for the Goodyear Tire & Rubber Co. Subsequently he was associated with J. W. Hobbs as metropolitan distributor of Lee tires. Recently he was connected with the Nassau Garage & Taxi Co., Rockville Center, L. I.

Changes with Mitchell

A. G. McMillan, who has been general manager of the New York branch of the Mitchell Motors Co., Inc., has been appointed director of sales at the factory in Racine. John Tainsh will continue as general sales manager under McMillan's direction. Paul C. Lott, connected with McMillan in New York, has been named sales promotion manager at the factory. G. N. Bliss will direct eastern sales, and Fred T. Yeager, western sales, for the company.

Schurch Directs Western Sales

John F. Schurch has been elected a vice-president of Manning, Maxwell & Moore, Inc., and has taken charge of its western sales, with headquarters at the company's Chicago office, 27 North Jefferson Street. Schurch was graduated from the University of Minnesota in 1893 and entered the service of the Minneapolis, St. Paul and Sault Ste. Marie Railroad, with which he was connected for several years, leaving that position to become associated with the Railway Materials Co. of Chicago. In 1914 he was elected vice-president of the T. H. Symington Co.

Hendee Promotes Whitney

P. B. Whitney, formerly manager of the Chicago branch of the Hendee Manufacturing Co., Springfield, Mass., has been appointed by the company as manager of the Southwestern district, which includes Texas, Oklahoma, Louisiana, Arkansas, Colorado and Wyoming. Whitney is a motorcycle engineer of many years' experience and has been through all the phases of the motorcycle since its inception, both in selling and manufacturing. His headquarters will be at Fort Worth.

Soglovitz in Canada

S. S. Soglovitz has been appointed sales supervisor in the Province of Quebec for the Maxwell Motor Co. of Canada, Ltd. Formerly he was associated with the Cleveland Tractor Co. as a sales supervisor in Europe, North Africa, Canada and the United States. Soglovitz was connected with the Ferro Motor Co. and the White and Peerless companies in the early days of the industry.

Rickenbacker Appoints Whitley

J. W. Whitley has been named southeastern supervisor for the Rickenbacker Motor Co., with headquarters at Atlanta. Whitley is well known in the southern automobile territory, having been operating there for the past twelve years, during the last nine of which he was associated with the Saxon Motor Car Corp.

Stephens Is District Manager

H. M. Stephens has been appointed district manager for the Cadillac Motor Car Co. in the eastern states, having been a special representative for the company during the past year. Stephens was construction engineer of the new Cadillac factory in Detroit.

McKeen Made Sales Head

C. H. McKeen has been appointed sales manager of the Apco Manufacturing Co., Providence. He has been covering the East for the company ever since he became associated with it, ten years ago.

Plants Speeding Up in All Branches of the Industry

G. M. Truck Shipments Increase

PONTIAC, MICH., June 5.—W. L. Day, general manager of the General Motors Truck Co., declares May was the biggest month in the plant's history since 1919, when it was exceeded by only one or two months. This summary is based on orders received. Special equipment orders have held back shipment somewhat, but there has also been a large increase in shipments over the April record and any previous month since 1919.

"We base our opinions of the market and the prospects for coming business," said Day, "on the dealers' weekly retail reports. These have been showing a steady improvement for a long time and we are consequently feeling confident in the future prospect. There doesn't appear to be any let-up ahead. Orders now in hand and commitments made point to a still stronger production month in June."

Gray & Davis Improving

BOSTON, June 3—The Cambridge factory of Gray & Davis, Inc., is turning out more motors on a 1200 daily schedule than it did for an entire month six months ago. The average daily output for a sustained period is reported to be the largest on record. Monthly shipments show a steady gain since the first of the year. April was the best month of the year in point of net, and its average is expected to be maintained for several more months. Its production was 20,000. May is expected to show an output of 25,000.

Ford Output at Atlanta Greater

ATLANTA, June 5—The local plant of the Ford Motor Co. increased its output to 150 cars a day beginning June 1, and employed 75 more men. The present force is 350 men. When the plant reopened a few weeks ago its output was 75 cars a day, this being increased subsequently to 100. Increased orders made a further expansion of the output schedule mandatory. The new schedule is the largest attempted at the plant.

Packard Exports Grow

DETROIT, June 5—Packard Motor Car Co. states that its export business in passenger cars is showing marked improvement, shipments for the first four months of the year being 50 per cent better than the corresponding period in 1921. Truck sales abroad also show some improvement, Japan, especially, making purchases in larger volume.

Franklin Plans Big June

SYRACUSE, N. Y., June 3—Franklin Automobile Co. reports orders for June shipment equal in number to total shipments for May. Last month broke all previous records in the matter of retail deliveries of new Franklin cars into the hands of purchasers for a period running back twenty years. The company states that production for June will aggregate 1520 cars. More than 700 new employees have been taken on since April 1.

May Biggest Peerless Month

CLEVELAND, June 6—May was the largest sales month in the twenty-one years' history of the Peerless Motor Car Co., and June will eclipse May, according to prospects based on a comparison of orders at the beginning of the two months. Last month surpassed the previous record month, March, 1920. While production facilities at the factory have been adequate to meet all requirements with only small oversold conditions, these are being expanded as fast as is feasible so that with the continuance of the demand deliveries will not be hampered to any great extent.

Hendee Continuing Full Time

SPRINGFIELD, MASS., June 5—The Hendee Manufacturing Co. continues to run full time and has orders that will keep the factory at normal production for the next month. A second large order for Indian Scout motorcycles has been received from Holland; also a substantial order from South Africa for cycles of the various models. Numerous orders have been filled recently for machines for police departments.

May Big with Standard Parts

PONTIAC, MICH., June 6—Twenty-five per cent increase in May business over the April record is the report of B. A. Litchfield, general manager of the Standard Parts' plant here, making springs and axles. This concern, Litchfield says, had a bigger volume of business in May than in any month since 1920. The outlook for June, he said, is for an increase of about 25 per cent over May figures.

Oakland Speeding Up

PONTIAC, MICH., June 6—May business with the Oakland Motor Car Co., in actual shipments of cars from the plant, exceeded April output by 50 per cent, according to W. R. Tracy, assistant sales manager. Tracy says that the business in May was 125 per cent greater than that in May, 1921, and was the largest single month since September, 1920.

During June, he said, prospects are that there will be at least a 50 per cent increase over May's record, as orders ahead promise necessity of speeding up the production.

Bushing Company Expands

PONTIAC, MICH., June 3—The Pontiac Jig Bushing Co. has announced an expansion plan that includes purchase of several acres of land on the Grand Trunk railway here for factory buildings. The plant now occupied has been outgrown, and part of the work is being placed with other machine shops. The first unit of the plant is now being erected. O. R. Briney, president, declared to-day the scope of operations would be broadened as soon as more room is available, a national sales campaign entered upon, and other machined specialties put on the market.

R. & V. Increased 37 Per Cent

EAST MOLINE, ILL., June 6—R. & V. Motor Co.'s business in April increased 37 per cent over March, according to D. M. Beal, sales manager, who adds that field reports indicate that June may surpass the May record, which was the largest in the history of the organization. This is the biggest selling season in the 18 years of the company's operation. Closed car business in April gained 42 per cent over March. Production schedules on the Knight Six are being increased. A shortage of cars has already developed, a situation which will not be relieved for several weeks.

14,000 Studebakers Sold in May

SOUTH BEND, IND., June 2—President A. R. Erskine of the Studebaker Corp. announces that the production, sales and financial departments of that company shattered all previous records in May. Sales were approximately 14,000 cars and production 10,853 cars. Sales for May, 1921, were 7383. Collections by the company aggregated $17,000,000. Erskine asserts that there is no slackening in demand for the Studebaker products.

Bigger Output by Republic Tire

YOUNGSTOWN, June 5—Due to sustained improvement in casing demands the Republic Rubber Corp. is resuming tire production here, where the capacity is more than 4000 casings daily. At Canton the company is making 1500 tires a day, the output having been pushed beyond normal. Inner tube production by the company is being increased to 100,000 monthly, with some departments operating on three shifts.

Good Business at Springfield

SPRINGFIELD, OHIO, June 6—Good business during the month of May is reported by the heads of the Kelly-Springfield Motor Truck Co., Victor Rubber Co. and the Springfield works of the International Harvester Co. Prospects are considered bright for this month. The Westcott Motor Car Co. has been doing a good business the last two months.

Ford Plans to Make Aluminums in South

Manufacture of Cheap Fertilizers at Muscle Shoals Would Be Incidental

WASHINGTON, June 5.—The Committee on Military Affairs of the House has decided, by a vote of 12 to 9, to accept the proposal of Henry Ford for the development of the Government's vast power and nitrate projects at Muscle Shoals, Ala.

In reaching its decision the committee decided to eliminate from the properties covered in the Ford offer the steam plant at Gorgas, Ala., and it agreed with representatives of Ford on new language relating to the manufacture of fertilizer. In all other respects the Ford offer was fully approved.

To Make Furnace Steels Also

Production of electric furnace steels and aluminums will be the chief object of Ford if Congress finally accepts his offer to complete and lease the hydro-electric power plants at Muscle Shoals and purchase the nitrate plants, the Waco quarry and the Warror River steam plant. Manufacture of cheap fertilizers for the farmers of the country will be a big part of the undertaking, but it really will be incidental.

There has been much speculation as to the real purpose of Ford in making his proposal, and the final testimony of his chief engineer, William B. Mayo, before the Senate Committee on Agriculture and Forestry gave the first real clue. Mayo began giving his testimony before the House Committee on Military Affairs in February and continued on the stand periodically for three or four weeks, but he always evaded the question gracefully when asked to detail what his chief had in mind. It was not until his final appearance before the Senate Committee that Mayo told the secret.

Has Secret Process

Following is a verbatim report of part of the dialogue between Mayo and Senator Norris, chairman of the committee:

The Chairman. I would like to know why Mr. Ford has obligated himself to extract nitrates from the air by the process that, from all we can find out now, from scientific men, is not as good as the one he will not operate or will not obligate himself to operate for nitrates?

Mr. Mayo. Maybe you are mistaken in what offers. He does not obligate himself to operate nitrate plant No. 2 under the cyanamid process. He merely agrees to operate that plant at a certain capacity.

The Chairman. What process is he going to use there if he does not use the cyanamid process?

Mr. Mayo. He is not prepared to say, but he will have to equip it for whatever process he uses.

The Chairman. Do you mean to say he has some secret method that he is concealing that he is going to use?

Mr. Mayo. Yes, sir. Surely.

The Chairman. Can you give the committee this much information, that Mr. Ford, under that provision of the contract, does have in mind some other secret process that he expects to use instead of the cyanamid process?

Mr. Mayo. Yes, sir; and the process, we think, will be much safer and fully as cheap, if not cheaper, than the Haber process.

The Chairman. You feel under the proposition that he is obligated to make, then, at least 110,000 tons of nitrate a year?

Mr. Mayo. Its nitrogen capacity is equal to 110,000 tons of ammonium nitrate, and he sets that up as the equivalent.

The Chairman. Will Mr. Ford's secret process require as much power as this does?

Dovetails with Other Plans

Mr. Mayo. I don't think as much; no, sir.

The Chairman. How much less?

Mr. Mayo. We are not sure yet. It is being worked out to dovetail in with other manufacturing processes that are to be used in our own business.

The Chairman. Can you give the committee any idea as to how much power, under this new or secret process that Mr. Ford has, will be required to make 110,000 tons a year?

Mr. Mayo. I could not say offhand. As I say, it dovetails into other manufacturing processes.

The Chairman. What do you mean by dovetailing in?

Mr. Mayo. I mean the by-product of the one is the product of the other.

The Chairman. Can you give the committee any information as to what the other products are, whether by-products or otherwise, that you expect to make in the process?

Mr. Mayo. They will be electric furnace steels and aluminums.

The Chairman. Aluminums?

Mr. Mayo. Yes.

There are large deposits of bauxite in Georgia and in the region adjacent to Muscle Shoals. Bauxite is one of the sources of aluminum. The deposits near Muscle Shoals were at one time the principal source of this ore in the United States. Later, deposits in Arkansas came into the market, and more recently the Aluminum Co. of America obtained large sources in British Guiana.

Deposits Not of High Grade

The Arkansas-Alabama deposits are not, on the average, of high grade, but aluminum can be made from them. It is generally conceded that Ford can produce aluminum in large quantities much more cheaply than it can be purchased at present. Bauxite is the nearest thing in nature to alumina, which is refined from alunite. Bauxite contains 50 per cent alumina, which in turn is 53 per cent aluminum. It has been reported that Ford was considering the purchase of a large tract containing heavy alunite deposits which will be refined at Muscle Shoals if his offer is accepted by the Government.

By-products of alunite are potash and sulphuric acid.

Detroit Employment 50,000 Above 1921

Complete Recovery of Industry Seen by Government in Survey for May

(*Continued from page* 1299)

output. Another company in this city is running day and night shifts.

One motor company at Lansing is operating to the limit of its capacity, while an automobile body company is working overtime, employing 600 men.

Increased sales of automobiles and trucks have brought about a pronounced increase of employment in the automobile parts and accessories plants of Wisconsin.

In Ohio the automotive industry is running at full time. A report from Dayton, Ohio, says "The automotive industry has completely recuperated."

Employment Gains in Toledo

TOLEDO, June 6—The larger industries of Toledo showed a gain of 2146 workers in May for a total of 20,894 in the 21 plants normally employing 500 or more men, in a report made to the government.

A great share of the gain is shown in the automotive plants. The vehicle factories gained 1361 employees in May. The Willys-Overland Co. is now working 8625 men, which is 764 more than last month. The Milburn Wagon Co. placed 157 more men at work during the month, and the Toledo Chevrolet plant more than doubled its force.

The Electric Auto-Lite Corp., which is classed in the miscellaneous group, added 371 employees in May and now has 2173 at work. Other allied industries in the metal trades showed gains.

Tariff Bill Unchanged in Automobile Section

WASHINGTON, June 8—When the section of the tariff bill relating to automobiles came up before the Senate finance committee last night, it provoked little discussion and no change was made by the committee in the House rate of 25 ad valorem.

At the request of Senator McCumber, the Senate deferred action on a committee amendment proposing to strike out a proviso carrying a countervailing duty against automobiles from countries which impose a rate above 25 per cent on American made vehicles.

Senator Townsend of Michigan said he was more interested in a countervailing duty than in the straight duties proposed, explaining that he favored the same tariff treatment as the other countries accorded the United States.

PREPARE FOR ROAD MEETING

WASHINGTON, June 5 — The bimonthly meeting of the Highway and Highway Transportation Education Committee will be held here on June 9.

Demand by Dealers Forcing Big Output

Some Factories Placing Commitments for Parts 60 Days Ahead on Month's Basis

(*Continued from page* 1295)

production of 65 daily, which will be increased in June.

Studebaker is continuing production at the rate of 440 cars daily, the capacity of the several plants of the company. Paige reports that the 3800 production mark fixed for its Paige and Jewett models was exceeded in May and that further gains will be made in June. Columbia continues to be handicapped in the production of its light six through material shortages, but declares it will reach a production of 50 daily in June.

Other Schedules Increased

Other cars in the more popular price class are meeting with just as ready a sale as they can meet. Rickenbacker with 500 in May has outlined a schedule of 750 for June. Liberty is approximating 30 cars daily. Reo is building and shipping 130 cars and speed wagons daily on a five-day weekly basis. Saxon business is better, the schedule of 10 daily being exceeded in May, with good prospects of further gains in June.

In the higher priced group Cadillac is working steadily on a schedule in excess of 100 daily and reports a record day in May, in which 150 cars were produced and shipped. Packard declares its light six production to be on a schedule of 50 daily. Wills Sainte Claire, working two shifts, reports a record day in May, in which 80 cars were built and shipped, and declares its daily schedule to be 60 continuing into June.

In the General Motors group, Chevrolet production continues at the rate of about 1200 daily. Buick is building about 10,000 monthly. Oldsmobile has increased its schedule to 150 daily and is increasing its working force rapidly. Oakland is operating at a rate in excess of 100 cars daily.

Hampered by Material Shortage

Lincoln, handicapped by material shortages, operated at a rate of 30 cars daily. Handley-Knight and Roamer, Kalamazoo, report business in May better than April and indicating a continued growth in June.

Production on the Gray car was delayed owing to inability to get factory equipment installed and delay in material deliveries. Work on the factory addition is being rushed and will be completed June 15, officials said.

The new plant of the Durant company at Lansing, which will be devoted exclusively to the manufacture of the Star, will be completed in July and production will be started there in August.

Maxwell produced 6500 cars in the United States and Canada during May and shipped 6525, which are records with this company. In the week ended June 3, incoming business reached new high levels, with an average of 600 cars ordered daily.

Dort is working on a schedule of 80 to 90 daily, and reports itself 3000 behind on orders, which executives declare assures capacity production through June and into July.

MAY SHIPMENTS BY CARLOAD, DRIVEAWAY AND BOAT MADE IT HIGH RECORD MONTH

NEW YORK, June 7—The following table shows the factory shipment figures for the first five months of 1920, 1921 and 1922:

	Carloads			Driveaways			Boat		
	1920	1921	1922	1920	1921	1922	1920	1921	1922
January	20,057	6,485	15,241	29,283	3,185	7,397	....	93	154
February	25,505	9,986	19,600	43,719	1,507	9,950	....	99	169
March	29,236	16,287	27,380	57,273	9,939	15,800	....	75	264
April	17,147	20,187	30,200	64,634	14,197	22,500	....	1,619	3,200
May	21,977	18,608	33,810	74,286	15,193	28,710	....	2,381	7,220

Factory shipments for the other months of 1920 and 1921 follow:

	Carloads		Driveaways		Boat	
	1920	1921	1920	1921	1920	1921
June	22,516	20,269	60,746	18,384	8,350	3,947
July	23 082	19,470	52,342	15,320	8,702	3,725
August	23,386	20,350	34,060	14,290	7,095	3,565
September	20,804	20,150	24,431	13,550	5,469	3,580
October	17,209	17,323	14,127	11,257	2,519	2,300
November	13,253	14,061	9,497	10,509	659	1,385
December	11,802	12,100	6,469	7,500	89	134

252,000 Vehicles Output for Month

(*Continued from page* 1294)

other factors promise to prevent any sharp seasonal midsummer slump in sales.

Peak production and the avid demand for motor vehicles have brought manufacturing difficulties in their wake. Probably the most serious of these is labor. A shortage prevails in all branches of the industry and is responsible in large measure for the shortage of some essential parts. The companies hardest pressed to meet orders have been placed in the position of bidding against each other for help and this is forcing wage scales upward with a consequent increase in costs which will more than offset the prospective savings on freight rates. The situation in this respect appears most acute in the tire field, but parts makers are little better off.

Another factor which has increased production costs somewhat has been the willingness to pay premiums for immediate deliveries of some raw materials, especially malleables. This is the result of refusal to place commitments for more than one or two months ahead. There is no general disposition, however, to place orders for more than 60 days in advance for it is felt that it is wiser to pay small premiums than to pile up inventories.

Midwest Engine Plans Approved by Committee

INDIANAPOLIS, June 7—A reorganization committee has approved the plan under which the Midwest Engine Corp. will be organized to acquire the assets of the Midwest Engine Co. of Delaware and the Midwest Engine Co. of Indiana. The new company will have a capital of $5,000,000 in 7 per cent preferred stock, 125,000 shares of no par value common and $3,000,000 in 7 per cent 15 year mortgage bonds.

Under the plan creditors of the A and B classes will receive mortgage bonds in exchange for their claims, and creditors in the C class will receive preferred stock.

Preferred stockholders have been asked to subscribe to the new mortgage bonds to the extent of 35 per cent of the present holdings with the understanding that they will receive a bonus of 50 shares of common stock with each $1,000 worth of bonds purchased.

Expect Harding to Sign Post Office Road Bill

WASHINGTON, June 8—President Harding is expected to sign the Post Office appropriation bill which passed the House and Senate to-day. The bill is of importance to the automotive industry, as it authorizes the appropriation for a three year highway program. The report of the conferees recommending an authorization of $50,000,000 with certain contractural rights left to the states to protect their situations was accepted.

The conference report as approved by Congress provides for an authorization of an appropriation of $50,000,000 for the construction of post roads during the fiscal year 1923 and also carries authorizations but not actual appropriations for $65,000,000 in 1924 and $75,000,000 in 1925 and in addition $6,500,000 annually during these last two years for construction of forest roads.

Miniger Purchases Electric Auto-Lite

Pays Minimum Price of $4,700,000—Must Negotiate Contract with Overland

TOLEDO, June 8—The Electric Auto-Lite Corp., a division of the Willys Corp., was sold to Clement O. Miniger, at a special masters sale at the court house here to-day for the minimum price set by the Federal court of $4,700,000. The sale will be subject to the confirmation of the court, which will probably come on June 19. In the meantime, by the provision of the order of sale, Miniger will have to negotiate a satisfactory contract with the Willys-Overland Co. for manufacturing farm lighting outfits.

Miniger was the only bidder to qualify by the deposit of a certified check for $50,000. Special Masters Frank P. Kennison and Colonel Francis G. Caffey were present with their attorney, George P. Hahn, who immediately filed a report of the sale and a motion for its confirmation. Attorneys Thomas Tracy and Edward Marshal accompanied Miniger to the sale. No announcement was made as to the use of the newly incorporated Electric Auto-Lite Co. chartered last week.

Purchaser for New Process Gear

SYRACUSE, N. Y., June 8—A purchaser for the New Process Gear Co. of this city, a subsidiary of the Willys Corp., has been obtained, but George R. Lunn of Schenectady, receiver, refuses to reveal the name of the probable buyer. Lunn says that the local plant will not bring half as much as it is worth. The plant here is now employing 800 men, and night shifts are being operated. Enough orders have been received to keep the plant working during June and July.

M. A. M. A. Advertising Heads to Form Council

NEW YORK, June 7—Directors of the Motor and Accessory Manufacturers' Association at a meeting here today approved the organization of an advertising managers' council. One hundred companies which are members of the organization expressed a desire for the formation of such a division and pledged the interest of their advertising managers.

The first meeting of the council will be held in connection with the annual credit convention, which will be held Sept. 13, 14 and 15. The meeting place has not been decided. The convention this year will be of more general interest than it has been in the past with additional sessions devoted to exports, advertising, etc., as well as credit questions. There also will be departmental meetings.

The executive committee of the advertising managers' council will be headed by E. W. Clark of the Clark Equipment Co., Buchanan, Mich. The other members are S. E. Baldwin, advertising manager of the Willard Storage Battery Co., Cleveland; J. C. McQuiston, department of publicity of the Westinghouse Electric & Manufacturing Co.; Joseph S. Jacobs, advertising manager of the American Hammered Piston Ring Co., and M. Lincoln Schuster, manager of the educational department of the M. A. M. A., as secretary. The council will function through the educational department.

FINANCIAL NOTES

Wisconsin Motor Manufacturing Co., Milwaukee, manufacturer of the Wisconsin motor, is offering $1,240,000 of 8 per cent cumulative preferred stock, par value $100, and 12,400 shares of non-par valued common stock at a price of $101 per unit of one share of preferred and one of common. Upon completion of this financing, there will be $2,000,000 preferred authorized and outstanding, and 75,000 shares of no-par common authorized. The present financing is for the purpose of furnishing necessary working capital and placing the company in the proper financial position consistent with good business.

Mack Trucks, Inc., earnings in April were in excess of $400,000, an increase of more than $100,000 over March. Net profits totaled $255,197 after depreciation in the first quarter, compared to $4,395 in the corresponding quarter of 1921. March net earnings absorbed the slight customary seasonal loss in the first two months of the year leaving a profit for the quarter equal to the quarterly disbursements on the combined $16,252,891 7 per cent first and second preferred stock. March earnings alone were at a rate of more than three times in excess of the annual preferred dividend requirements.

Reynolds Spring Co. directors at a meeting this week will declare the 14 per cent accumulated preferred dividends on the Class B preferred stock as well as the regular quarterly dividend of 1¾ per cent on the cumulative preferred A stock. The annual rate of 7 per cent has been paid regularly on the preferred A stock since the organization of the company and 7 per cent has been paid regularly on the B stock through June 30, 1920.

Cole Motor Car Co. has paid the regular bi-annual dividend, amounting to 10 per cent, to all stockholders. For the last five years the stockholders have never been paid less than 20 per cent per annum.

Walden-Worcester, Inc., will make the first interest payment on its bonds delivered in December, 1921, under the reorganization agreement of August, 1921, on June 15 at Merchants National Bank, Worcester, Mass. These bonds which are temporary will be replaced by permanent bonds about that date.

Willys-Overland Co.'s arrangement with its bank creditors has become operative, according to Ralph Van Vechten, chairman of the bank creditors committee. Van Vechten states that all of 51 interested banks have deposited their notes for exchange into bonds to be issued under the arrangement.

Kelly-Springfield Tire Co. has declared the regular quarterly dividend of $1.50 a share on 6 per cent preferred stock, payable July 1 to stockholders of record June 16.

BANK CREDITS

Written exclusively for AUTOMOTIVE INDUSTRIES *by the Guaranty Trust Co., second largest bank in America.*

Call loans last week covered a range of from 4 per cent to 5½ per cent, as compared with 3½ per cent to 5 per cent in the preceding week. Increased firmness developed during the latter part of the week. In time money a firmer tendency was also noted, which was attributed in some quarters to the June 1 interest and dividend payments. The range was 4¼ per cent for 60 and 90 days' maturities, and 4¼ per cent to 4½ per cent for 4, 5 and 6 months' as against a range of 4 per cent to 4¼ per cent for all maturities in the previous week. The market was dull and no important transactions were recorded. The prime commercial rate remained unchanged at 4½.

Since June 1, the rate for sterling exchange has advanced more than 5½ cents, and on June 6 a high of $4.51¼ was reached, which is the highest since the summer of 1919. The reports of satisfactory progress of the negotiations at the Conference of International Bankers at Paris, and the general belief that the German reparations question is on the road to settlement, are probable factors in the rise of sterling.

The total commercial failures reported for May were 1803, the smallest number since last September. This marks a reduction of 7.4 per cent from April and 33.7 per cent from the high record of January.

Weekly bank clearings at the leading cities of the United States for the week ended June 1 aggregated $5,980,599,000, a loss of 12.8 per cent from the previous week, but a gain of 3.7 per cent over the corresponding week of last year. Outside of New York the total was $2,201,899,000, a decrease of 13.2 per cent from last week.

Howard B. Hall Elected President of Bethlehem

NEW YORK, June 7—Howard B. Hall, former vice-president of the Bethlehem Motors Corp., has been elected president of the reorganized company, which is now understood to be amply financed so that it can immediately reenter the truck manufacturing field.

M. Herbert Beary has been appointed special representative of the new company.

Other officers of the new company are W. H. Rodgers, secretary and assistant treasurer; D. C. Smith, factory manager of the Allentown plant; Louis K. Gordon, former associate engineer of Mack Trucks, Inc., and designer of the original Bethlehem trucks, chief engineer and purchasing agent, and W. H. R. Sandalls, factory manager at Pottstown.

SMALL PARKER CAR

MONTREAL, QUE., May 29—The Parker Motor Car Co., Ltd., announces it is developing a small air-cooled car which will be a companion to the Parker Six.

N.A.C.C. Directors Discuss May Output

Believe Decline in Sales Inevitable Before Long—Consider Time Payments

NEW YORK, June 7—The astounding production of passenger cars and trucks in May was the subject uppermost in the minds of the directors of the National Automobile Chamber of Commerce at their meeting here to-day. The total ran far ahead of the most sanguine expectations.

While naturally gratified at the remarkable business they are enjoying, announcement of the total for May had something of a sobering effect. It was felt that the industry could not continue indefinitely to operate at top speed, and that some decline in sales is inevitable before long.

Reports from all sections of the country indicate, however, that there are as yet no signs of slowing up. Practically the only weak spots in the country are Maine and Georgia, and it was reported that sales in Maine were 50 per cent better than in April. Several states report sales 100 per cent better than a year ago. Included in this list were Michigan, Iowa, Nebraska and Virginia.

Dealers generally report that June prospects are bright. This applies not only to passenger cars but trucks. May sales of trucks were larger than in April.

One significant fact reported was that the number of sales made on time is decreasing, and that there was more cash business in May. The directors nevertheless gave considerable attention to the financing of time sales, and it was the general opinion that manufacturers must do more to assist their dealers in this respect in the future than they have in the past.

There has been a marked improvement in the trading situation, and the used car market is growing steadily better.

Exports are increasing steadily. Foreign sales of passenger cars in April were 49 per cent more than in March and sales of trucks were 44 per cent greater.

The directors expressed frank alarm because of what they considered unjust motor vehicle regulations proposed in various states. They felt that the time has come for dealer associations to make vigorous representation to their state legislatures against discriminatory laws.

Barnes to Address Members

NEW YORK, June 8—Julius H. Barnes, newly elected president of the Chamber of Commerce of the United States and head of the United States Grain Administration during the war, will address the members of the National Automobile Chamber of Commerce at their annual meeting to-day. The subject will be "Transport and Human Progress."

Members of the N. A. C. C. will meet at 10 a. m. The first business will be the election of five directors to take the places of those whose terms expire. Barnes' address will be followed by luncheon after which there will be a meeting of the committee headed by F. E. Moskovics to discuss simplification of manufacturing methods with representatives of the division of simplified practice of the Department of Commerce.

Motor truck members of the N. A. C. C. will meet in the afternoon. The chief topic to be discussed by the members will be the business outlook for the remainder of the year.

Truck registration figures will be one of the important topics discussed at this session. The data available from the various states on truck registrations are confused and unsatisfactory at the present time, so that careful market analysis is extremely difficult. The possibilities of remedying this condition will be considered by the truck members.

Other topics for discussion will include the reimportation of war trucks, advertising ethics, appraisal of used trucks, specifications in municipal truck bids and the Frelinghuysen bill now before the Senate, designed to bring back A. E. F. trucks from Germany for use in road building in this country. Standard caution plates for trucks in all states will also be discussed.

Truck Committee Meets

NEW YORK, June 6—Progress was made toward a coordination of ideas on truck regulations when a sub-committee of the N. A. C. C. truck committee met with a sub-committee of the Association of Motor Vehicle Administrators here yesterday. The latter association comprises the motor vehicle commissioners of the six New England states and the states of New York, New Jersey, Pennsylvania and Maryland.

The topics discussed included truck weights, capacities, speeds and dimensions. There was comparatively slight divergence of opinion on these subjects among the members of the two sub-committees. The recommendations resulting from the conference will be brought before the N. A. C. C. truck committee at the annual meeting in this city on Thursday.

INDUSTRIAL NOTES

Morse Chain Co. has completed plans for the erection of a factory on the Detroit Terminal Railroad which will give it 60,000 sq. ft. of manufacturing space and be ready for occupancy by Oct. 1. The branch factory located here for the past two years has become inadequate. The main plant will be continued at Ithaca, N. Y. The Detroit factory will specialize in the manufacture of sprockets and adjustments required for the operation of the chain on the various types of engines now employing them. In connection with its plans for increasing its production facilities, the company will broaden its engineering staff located in Detroit. F. C. Thompson is manager of the Detroit branch.

Smith-Springfield Body Corp. has had an attachment filed against it at the registry of deeds in Springfield, Mass., in an action on contract for $35,000 brought by A. Waxman & Co. of Philadelphia.

METAL MARKETS

Third quarter prices for steel products are in the formative stage with automotive demand furnishing the chief prop for arguments in support of price advances. Quite a few of the sheet mills expect to carry a considerable quota of unfilled orders over into the third quarter, and there are those who consider such a condition in itself justifying a higher range of prices. On the other hand, those producers who hold that if ever there was need of a conservative policy with reference to prices, it is the present with its many adverse currents and cross-currents, are standing on solid ground.

Among those who mould the steel industry's price policy responsibility for maintaining price levels on a sound basis is felt perhaps a trifle more keenly at this time than usually because the steel industry as a whole is once more under fire from legislative inquisitors. Runaway market conditions would only add fuel to the comments of sensational newspapers. Moreover, certain reductions in production costs are about to mature, and in the face of these too sharp price advances would appear indefensible. Iron ore for the 1922 season is certain to be at least 50 cents a ton lower than last year. The 10 per cent reduction in freight rates which goes into effect July 1 is also destined to lower costs, although perhaps not as much as some consumers imagine.

All in all, moderation in the matter of prices fits nicely into the program of those producers who oppose jeopardizing the permanent welfare of their industry by taking advantage of the high spots in the demand while it is still below normal on the whole. Meanwhile sight must not be lost of the influence which those automotive purchasing agents continue to exert on the market who offer premiums for quick deliveries of material which they should have provided for earlier in the season. Such an offer of $10 premium on 500 tons of No. 22 automobile body stock is reported to have been made to a Mahoning Valley rolling mill a few days ago and turned down. The effect of the report on the market was, however, not lost.

Pig Iron.—Most of the automotive foundries are waiting until July 1 when the 10 per cent reduction in freight rates goes into effect before placing new orders. Foundries making castings for the Ford Motor Co. are quietly sounding the market regarding the tonnages they will have to buy as the result of notice to them that they will receive no iron from the Ford Motor Co.'s blast furnaces over the next three months.

Steel.—Some makers of cold-drawn steel bars appear to be out of the market; at least they are quoting prices which discourage fresh buying and which are considerably higher than the nominal 2¢ market. The market for strip steel continues strong, especially so for the cold-rolled variety. Sheet bars continue to show a wide range. For bolts and nuts even higher prices than those established by the recent advance are predicted in the Pittsburgh market.

Aluminum.—In the matter of prices every importer appears to be a law unto himself with outside holders of speculative lots cutting a fraction under the prices asked by regular importers.

Copper.—Detroit continues to buy large tonnages of Lake copper. New England rolling mills are also taking on copper and much of their production is reshipped to Michigan automotive consumers. The market is fairly steady.

Calendar

SHOWS

Nov. 13-18 — Chicago, Annual Show and Meeting of the Automotive Equipment Association.

FOREIGN SHOWS

March 10-July 31—Tokio, Japan, Peace Exhibition.

July 1-24—London (Olympia), Aircraft Exhibition.

Sept. 1922 — Rio de Janeiro, Brazil, Automobile Exhibits in Connection with the Brazilian Centenary Associação Automobilista Brazileria.

Sept. 15-20—The Hague, Automobile Show.

Sept. 25-Oct. 3—Berlin, Automobile Show at the Kaiserdamm Hall under the auspices of the German Automobile Manufacturers Association.

September — Buenos Aires, Argentina, Annual Exhibition, Sociedad Rural Argentina.

Oct. 4-15 — Paris, Automobile Show, Grand Palais.

Nov. 3-11 — London (Olympia), Automobile Show.

Nov. 10 - Dec. 19 — Brussels, Automobile Show, Palais de la Cinquantenaire.

Nov. 29-Dec. 4—London (Olympia), Cycle and Motorcycle Show, British Cycle Motors, The Tower, Warwick Road, Coventry.

November—Buenos Aires, Argentina, Annual Exhibition, Automovil Club Argentino.

RACES

July 15 — Strasbourg, French Grand Prix.

CONVENTIONS

June 11-15—Milwaukee Annual International Convention of the Associated Advertising Clubs of the World.

June 19-20 — Detroit, Summer Convention of the Automobile Body Builders Association.

June 19-24—Colorado Springs, Summer Meeting, Automotive Equipment Association.

June 26-July 1—Atlantic City, Twenty-fifth Annual Meeting of the American Society for Testing Materials, Chalfonte-Haddon Hall Hotel.

August 28-Sept. 2 — Detroit National Safety Congress.

Sept. 18-23, 1922—Rome, Italy, Second Annual Meeting of the International Chamber of Commerce.

S. A. E. MEETINGS

June 20-24 — White Sulphur Springs, W. Va., 1922 Summer Meeting of Society of Automotive Engineers.

Rail Rates for Milk Popularizing Trucks

WASHINGTON, July 7—The adoption of automotive equipment for the 200,000 milk producers and shippers who are members of the National Milk Producers Federation and its twenty-six allied associations, will be taken up Friday at a conference of the national directors and members of the executive committee of that association, called to Washington for special consideration of the milk producers' transportation problem.

In an interview to-day with AUTOMOTIVE INDUSTRIES the possibilities of 100 per cent automotive transportation on short line milk hauls were outlined by Charles Holman, executive secretary of the association, who expressed the opinion, based on a survey of the situation, that within three to five years practically all of short haul milk transportation would be done by motor trucks.

"The recent 10 per cent reduction in freight rates did not benefit the milk producers," Holman said. "All milk or, at least, practically all milk and cream that is carried by rail is transported by passenger trains and carries a passenger rate. So high have become these rates that the milk producers can no longer bear the burden of railroad transportation and our solution seems to lie in automobile transportation."

Have Appealed to I. C. C.

While little hope is entertained for favorable action on it, the milk federation has filed a petition with the Interstate Commerce Commission setting forth that in justice to its industry the rates on milk and cream must be reduced.

The relative cost of automobile transportation vs. railroad transportation on short line hauls from actual figures based on a survey in Minneapolis has been cited before the I. C. C. The "milk sheds" of Minneapolis comprise a radius of approximately 30 miles. The motor truck rate into Minneapolis from this zone is 15 cents per hundred pounds. The rail rate is 28 cents per hundred. Added to the rail rate is a pick-up charge of 5 cents per hundred and a delivery charge, from depot to milk station of 5 cents, making a total of 38 cents per hundred pounds when shipped over the railroad, compared to 15 cents by truck.

As a result of this wide difference in freight rates practically all the milk and cream from the Minneapolis "milk sheds" is now being transported by automotive equipment. So developed has become the motor vehicle transportation system in that city that it has resulted in what is believed to be the initial appearance of glass lined trucks of similar construction to regular motor trucks, for hauling large quantities of milk.

In discussing the possibilities of automotive transportation for the 200,000 milk producers, Holman declared that in his belief the glass lined trucks would open up a new field for the manufacturer.

With possibly three exceptions, the opinion has been expressed that trucks may haul economically, admitting good roads are available, the entire production of milk consumed in the urban districts. These three exceptions are New York, Chicago and Philadelphia.

Hart-Parr Co. Model 30, $400 Below Past Lists

CHARLES CITY, IOWA, June 2—Slashing price reductions on its tractor models, effective June 1, are announced by the Hart-Parr Co. They are:

	Old Price	New Price
Model-20	$945	$765
Model-30	1,295	895

The new price of the model 30 is $700 below the peak of 1921 and $400 less than it ever has been listed before. The new price of the model 20 is $430 below the peak price of 1921.

NATIONAL REDUCES PRICES

INDIANAPOLIS, June 2—The National Motor Car & Vehicle Corp. announces a price cut on National cars effective June 1 with the 7-passenger phaeton at $2,375; 4-passenger phaeton and 3-passenger roadster, $2,475; close coupled 4-passenger sedan, $3,250; coupe, $3,725; 7-passenger sedan, $3,825; Newport 4-passenger phaeton, $3,025, and 7-passenger Newport with all season top, $3,150. On the 7-passenger phaeton this represents a price reduction of $375.

Women Make Charges on Page Stock Sale

NEW YORK, June 7—An investigation of the affairs of the Pagé Motors Corp. of 522 Fifth Avenue is being conducted by the District Attorney's office upon complaint by two women that stock in the company was sold them under misrepresentation. Nicholas Pullman, a former chauffeur for Otto H. Kahn, who is sales manager for the company, has been summoned to court for examination.

Assistant District Attorney Pecora asserts that he has in his possession a report alleged to have been issued by the Pagé corporation on March 11 last and signed by Thomas R. Mead, vice-president and treasurer, which declares the assets were $7,284,770 and the surplus $5,854,770. Pecora declares inspection of the report revealed that $5,000,000 of the surplus was set down to the use of the name of Victor W. Pagé, president and chief engineer of the company, which is a Delaware corporation. He was described in the report as an "internationally recognized automotive engineering authority."

The complainants against Pullman allege they were informed by him that the company had sold 40,000 engines in Mexico and that the company paid 10 per cent dividends the preceding year.

The Pagé Motors Corp. has 600 feet of floor space in the plant of the Raymond Engineering Co. at Farmingdale, L. I., and has purchased land for a plant at Stamford, Conn., on which one building has been erected at a cost of about $17,000.

JEWETT ROADSTER, $1,065

DETROIT, June 3—The Jewett roadster, the latest addition to the Jewett line, will start production about July 1. It has a single straight seat, wide enough for three passengers, and is featured by a large baggage compartment in the rear, and by curtains which open and close with the doors to give good vision and a weathertight fit. The upholstering, as in the phaeton, is of genuine cowhide. The roadster is mounted on a standard Jewett chassis.